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Society of Motion Picture and Television Engineers

Volume 58 : January — June 1952

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Continuous Motion Picture Projector for Use in Television Film Scanning

By A. G. JENSEN, R. E. GRAHAM and C. F. MATTKE

The projector used for this equipment drives a 35mm motion picture film at the standard (nonintermittent) speed of 24 frame/sec and produces a television signal of 525 lines and 30 frames interlaced 2 to 1. The projector utilizes a system of movable plane mirrors mounted on a rotating drum and controlled by a single stationary cam. Vertical jitter in the television image is minimized by means of an electronic servo system operating on the film sprocket holes, resulting in a residual vertical motion of about 1/2000 of a picture height. A second electronic servo system is incorporated to suppress flicker. The combination of this scanner and a high-grade monitor is capable of producing a television picture with a resolution corresponding to about 8 mc and with good tone rendition over a range up to 200 to 1.

THE PROBLEM of designing a motion picture projector, in which the film motion is continuous, has occupied inventors and designers almost since motion pictures first made their appearance. In the early days of motion pictures the need for a continuous projector stemmed largely from a desire to decrease the wear and tear suffered by the film in the intermittent projector. Later on, with the advent of sound pictures, it was felt that a continuous projector could fit in better with a machine in which the film had to move continuously through the soundhead.

Many different types have been proposed and patented but very few of them have gone beyond the experimental stage. A measure of the interest in this problem may be obtained from the bibliography at the end of this paper in which are listed the more important papers published on the subject during the years 1920–1945.

One particular type of continuous projector, the Mechau projector, did reach the commercial stage and was used in a limited number of German motion picture theaters in the 1930's.[1] This projector used eight movable mirrors, the motion of each mirror being con-

Presented on October 15, 1951, at the Society's Convention at Hollywood, by A. G. Jensen, R. E. Graham and C. F. Mattke, Bell Telephone Laboratories, Murray Hill, N.J.

[1] L. Burmester und E. Mechau, "Untersuchung der mechanischen und optischen Grundlagen des Mechau-Projektors," *Die Kinotechnik, 10:* 395–401, 423–426 and 447–451, Aug. 5, Aug. 20 and Sept. 5, 1928.

trolled by its own individual cam of rather intricate design. The mechanical portion of this machine is rather complicated and expensive and is difficult to keep in good running order. However, the machine has high light efficiency and, when properly serviced, does produce high-quality pictures.

With the coming of television the need for a satisfactory continuous projector again became apparent. Such a projector would lend itself admirably to translating the 24-frame/sec film picture into a 30-frame/sec television picture as called for by the present television broadcasting standards. In a continuous projector the motion of the film frames is in effect frozen in some image plane, and in this image plane it is then possible to scan the picture 30 times per second, or at any other desired rate, synchronous or nonsynchronous, for that matter. The British Broadcasting Company realized this many years ago and installed a German Mechau projector as a film scanner in their Alexandra Palace studio. One or more of these Mechaus are still being used for that purpose in London.

In the U.S.A. present commercial film scanners use a 24-frame/sec intermittent drive in combination with a storage-type camera tube such as an iconoscope. Very short, intense light pulses are flashed through the film frame onto the storage mosaic, which is then scanned between light flashes at 60 fields per second, interlaced, making 30 complete television pictures per second. Thus every other film frame is scanned twice, and the remaining frames, three times.

Unfortunately the iconoscope does not have a very good contrast range and inherent in the storage action are certain spurious signals which must be eliminated by introducing so-called shading or compensating signals, a fact which further tends to degrade the contrast. The result is that presently produced television signals from motion picture film are generally not as satisfactory as good direct pickup pictures.

In the Bell Telephone Laboratories there has been a need for high-grade television signals ever since the first development of wide-band television transmission facilities around 1935. Such signals are needed for test purposes and for determining the fundamental transmission requirements for components of wide-band circuits such as the coaxial cable and the microwave link. For this purpose several film scanners have been developed in the past.

The first of these was used to demonstrate the transmission of 240-line, 24-frame television signals over the early New York-Philadelphia coaxial cable in 1937.[2] It was a mechanical scanner using for the scanning unit a 6-ft disk with 240 lenses mounted along the periphery and rotating at 1440 rpm.

As the requirements for good definition went up, mechanical scanners became impractical, and a new electronic film scanner was developed and first used in the transmission of 441-line, 30-frame (60 fields interlaced) television signals over the later New York-Philadelphia coaxial cable circuit in 1941.[3] This film scanner employs specially prepared 60-frame/sec motion picture film, continuous film motion, and a Farnsworth dissector tube, which is a nonstorage device. The continuous motion of the film furnishes the vertical scan for the pickup so that only a horizontal scan is required of the dissector tube. The equipment has since been redesigned to produce 525-line, 30-frame pictures as presently standardized, and was used for transmitting television signals over the New York-Boston microwave relay in 1947. The pictures from this scanner show very good detail and a wide range

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[2] M. E. Strieby, "Coaxial cable system for television transmission," *Bell System Tech. J.*, *17:* 438–457, July 1938.

[3] A. G. Jensen, "Film scanner for use in television transmission tests," *Proc. IRE*, *29:* 243–249, May 1941.

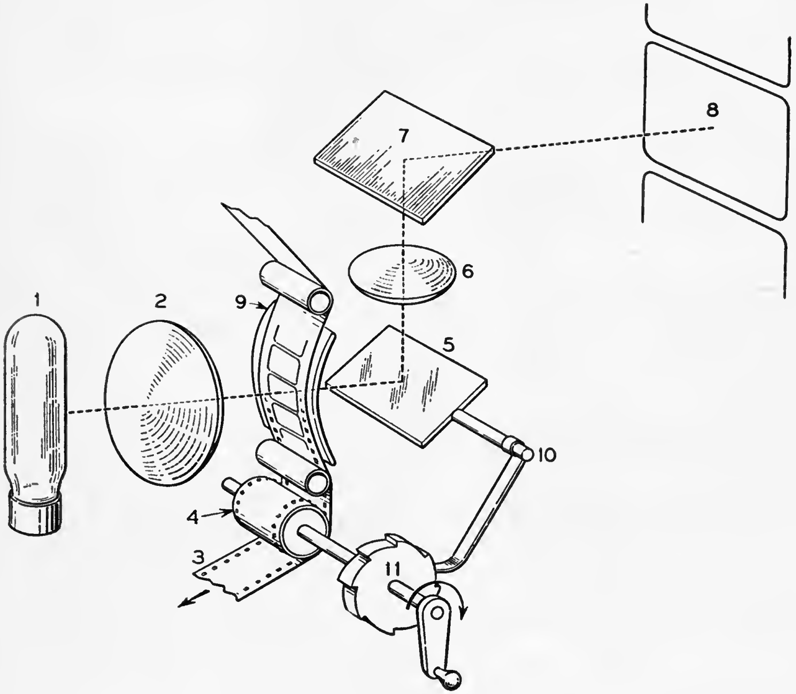


Fig. 1. Basic principle of operation of continuous projector.

of contrast, and the signals are still being used for test purposes in the laboratory. The chief shortcoming of this film scanner is the inconvenience and high cost of preparing the special 60-frame/sec film.

In order to obtain a wider range of picture material for test purposes, it was decided therefore to develop a continuous projector film scanner capable of using standard 24-frame/sec motion picture film. The design of such a scanner was made more feasible by the development of cathode-ray tube spot scanners with very short decay phosphors. Tubes of this type had been used with photomultipliers to produce television signals from still slides, and the resulting pictures showed very good resolution and a wide range of contrast.

In designing the optical system of this projector it was decided, as in the Mechau projector, to use a moving mirror system, since systems involving such mirror optics appear to have the best light efficiency, and freedom from certain refractive optics limitations. The design as evolved greatly simplifies the mechanical construction and operation by controlling all the mirrors from one simple stationary cam. During the development of the machine, further features were incorporated, such as an electrooptical servo system to eliminate picture jitter due to nonuniform film motion, and a second servo system to eliminate flicker due to nonuniform light efficiency through the frame cycle. The result is a laboratory model of a film scanner which is now being used for producing test signals and which is described in detail below.

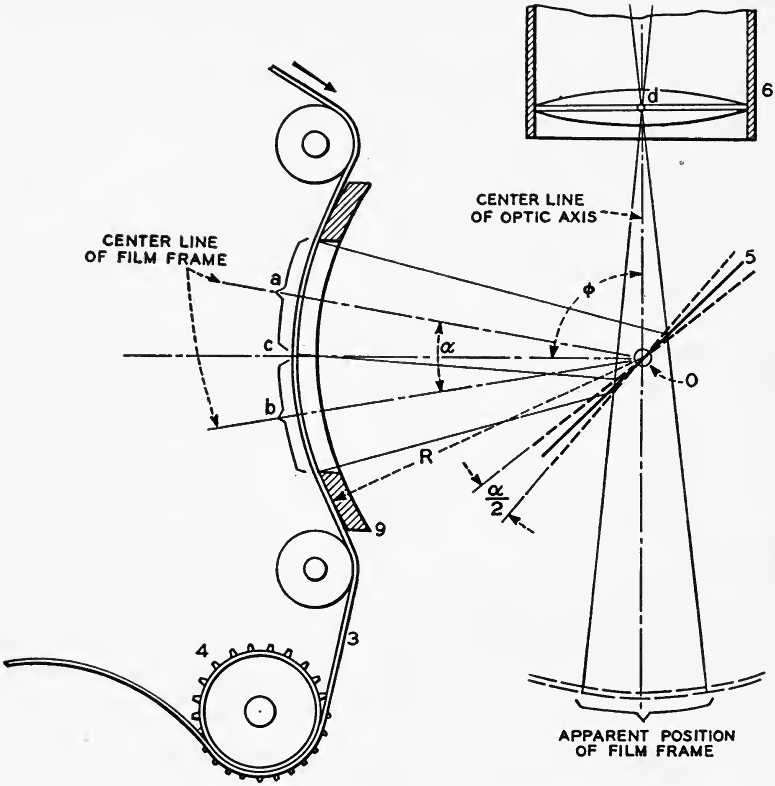


Fig. 2. Geometric relationship between film and moving mirror in continuous projector.

Fundamental Principles

The basic principle of operation of the machine used as an optical projector is shown on Fig. 1. Film 3 is moved at a uniform rate by sprocket 4 down over curved gate 9. Light from lamp 1 passing through condensing lens 2 and film 3 is reflected by compensating mirror 5 through objective lens 6 and reflected from fixed mirror 7 to screen 8. As sprocket 4 is rotated to move film 3, mirror 5 is caused to rotate about axis 10 by cam 11. The amount of rotation of mirror 5 is such that the image of the film on the screen produced by lens 6 remains stationary.

The geometric relation between film 3 and the mirror 5 is shown in Fig. 2. Consider the horizontal line CO passing through the center of the aperture in gate 9 and the center of curvature O of gate 9, as a fixed horizontal optical axis; also the radial lines aO and bO passing through the centers of two adjacent film frames a and b of film 3 and point O to form an angle α. Also consider line dO as a fixed optical axis passing through point O and the nodal point d of objective lens 6. Finally consider the reflecting surface 5 of a mirror pivoted about point O.

The requirement for optical compensation of the moving film is as follows:

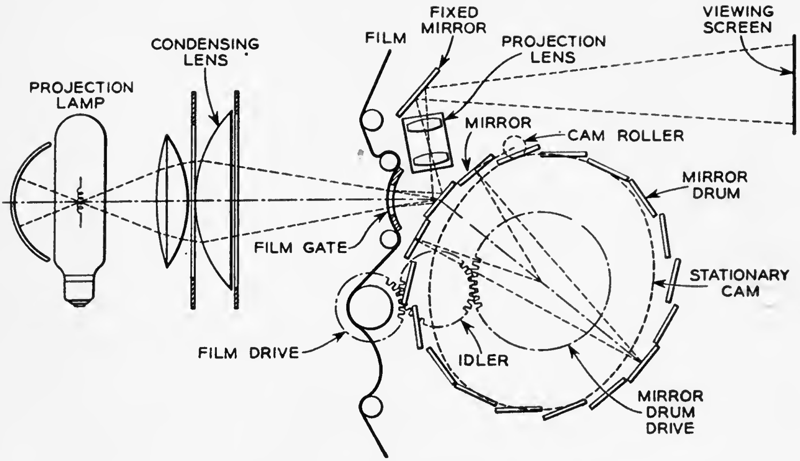


Fig. 3. Schematic diagram of mirror drum arrangement.

When a ray of light aO moves through the angle α to bO, the direction of the reflected ray Od must remain stationary.

This is accomplished by the rotation of mirror 5 about point O through an angle $\alpha/2$ while the film moves through the angle α.

Optically speaking, during the motion of the film through the gate, frame a appears stationary to lens 6, i.e., the apparent position of the film frame has not changed, as indicated on the figure.

The ratchet action suggested in Fig. 1 is obviously not suitable for any practical working mechanism. Therefore, for continuity of projection, the action of mirror 5 is made repetitive by using a suitable number of axially mounted mirrors equally spaced in a circle to form a sort of drum, the axes of the mirrors lying in the plane of the mirror reflecting surfaces and all parallel to the axis of the drum. As the drum rotates, the mirrors are then made to rotate at the required rate about their axes, by means of a suitable cam action. Figure 3 shows a schematic diagram of the mechanism. The mirror drum is geared directly to the film-drive sprocket, and as the drum rotates the individual mirrors are rotated through the required angle by means of cam followers rolling on a common stationary cam.

The continuity of the action of the mirrors is shown in Figs. 4a and 4b, where 4a shows one mirror at the middle of its compensation cycle and 4b shows two adjacent mirrors at the extremities of their compensating cycle. The axes e, h and j (perpendicular to the plane of the diagram) of the three mirrors shown are located on the arc of a circle with center of rotation at point d, the axis of the drum. Line Of is a diameter of the circle and lines de, dh and dj are radii to the mirror axes e, h and j. If the angles hde and hdj are both equal to β then the geometry of the system makes the angles efh and jfh both equal to $\beta/2$. Also lines drawn through e, h or j, perpendicular, respectively, to ef, hf and jf, will all pass through point O.

Referring to Fig. 2 it is seen that the angle α of the arc subtended by a film frame is equal to the angle β of the corresponding rotation of the mirror drum. It follows, therefore, that for proper compensation of film motion, the reflecting planes of the mirrors must at all times contain the respective per-

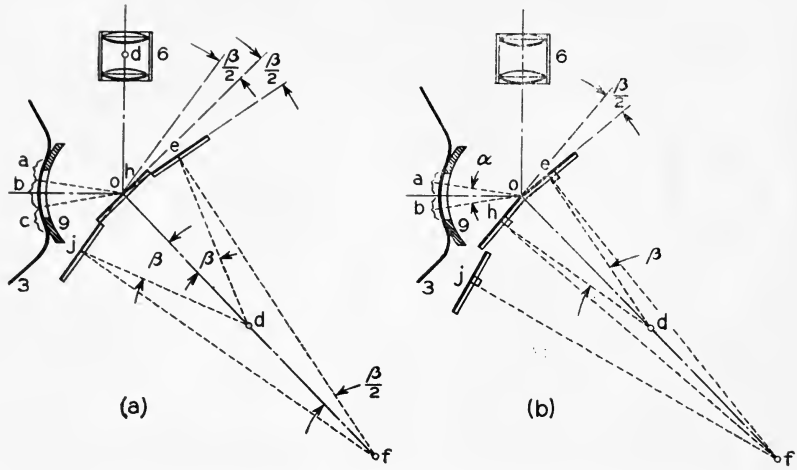


Fig. 4. Diagram illustrating proper motion of mirror through active compensation cycle. (a) One mirror at the middle of cycle; (b) two adjacent mirrors at overlapping part of cycle.

pendicular through e, h or j. In other words, during the active cycle the reflecting plane of a mirror must at all times contain the point O.

As the drum rotates and the mirrors obey the geometric principles just outlined, the reflected ray Od remains stationary while the film moves from a to b through angle α. Figure 4a shows the mirror in a position when frame b is at the center of the aperture in the gate, while Fig. 4b shows the mirror positions when the frame is at the limit of its travel in the gate.

Film Shrinkage

So far in this discussion, the consideration of the principles involved in the mechanism has been theoretical. It may be assumed that the mechanical parts can be made and assembled with the degree of accuracy necessary to satisfy the geometrical requirements for successful performance. On the other hand, the film is a plastic and therefore is mechanically unstable throughout its useful life. This instability must be considered in the design and suitable adjustment provided.

Standard 35mm motion picture film has a nominal frame pitch dimension of 0.748 in.; normal shrinkage, however, changes this value. In this projector design the longitudinal shrinkage requires consideration since its effect manifests itself at the curved gate by altering the angle subtended by a frame.

Referring to Fig. 2, it will be remembered that one picture frame (or really one frame pitch) in the curved gate should subtend an angle $\alpha = \beta$ for proper operation. As the film shrinks this angle α decreases and no longer corresponds to the associated mirror drum angular rotation of β, thus resulting in a frame-to-frame jitter of the projected picture. Exact compensation for shrinkage would require that the curvature of the film gate be increased, but for normal shrinkage it has been found adequate simply to move the gate a little closer to the mirror drum until a film frame again subtends the proper angle. Such an adjustment is provided for in the machine, together with a corresponding focusing adjustment of the projection lens.

Mechanical Specifications

So far the machine has been described in terms of a conventional optical projector and as such is shown in the schematic diagram of Fig. 3. In order to convert it into a film scanner all that is necessary is to replace the viewing screen in Fig. 3 by a cathode-ray spot scanning tube and to replace the projection lamp by a photomultiplier tube. As long as the projection lens is such as to provide the proper reduction from spot scanner raster size to film frame size, the remaining components of the machine are unchanged.

The geometric relations of these components are established by the choice of 18 compensating mirrors in the drum and an 8-frame drive sprocket as follows:

1. Angle α equal to frame pitch on the curved gate .	20°
2. Angular separation β between adjacent mirror axes on the drum	20°
3. Radius R of curved gate .	2.142 in.
4. Angle of rotation of the mirrors about their axes while traversing the active arc	10°
5. Rotational speed of drum .	80 rpm
6. Number of mirrors in drum	18
7. Number of teeth on drive sprocket	32
8. Number of frames per revolution of drive sprocket	8

Constructional Details

Film drive. The drive is of more or less conventional design incorporating the usual feed sprockets, idlers and drive sprocket. A friction-controlled film-tensioning sprocket immediately above the gate serves to keep the film taut during its passage through the gate, in order to insure proper radius of curvature while it is being scanned.

Mirror assembly. The outer diameter of the mirror drum is about 14 in. and it has 18 equally spaced mirror units mounted along the periphery on a diameter of $11\frac{1}{2}$ in. The general arrangement may be seen from the photographs in Fig. 5 and Fig. 6.

An individual mirror unit as shown in Fig. 7 consists of bearing housing 1, mirror support casting 2, shaft 3, mirror 4, bearings 5, bearing spacer 6, lock nut 7, mounting screws 8 and mirror setscrews 9.

The bearing housing is accurately machined to fit the holes in the drum. In order to maintain the necessary locational accuracy and allow easy assembly, the finished bearing cylinders are etched except for four contact areas as shown in Fig. 7. These areas are located about the threaded clamp screw hole, and when in place are the only surfaces that are in contact with the drum bore.

The shaft 3 is mounted in the shell on two ball bearings, preloaded by the proper adjustment of the spacer 6 to eliminate any radial motion. The mirror support casting 2 is mounted on the flange of the shaft. The contact face of the flange is machined after assembly in the shell to insure an accurate alignment of the casting 2. The corresponding face of the casting 2 is also machined on a special fixture to insure an accurate 90° angle between the mirror face and the flange face.

The casting 2 is designed with machined pads with steel ball inserts, which support and locate the mirror at the reflecting surface, the mirrors being of the front-surface type.

The mirrors are made of glass $2 \times 3 \times \frac{1}{4}$ in. thick, and the surface is flat to one wavelength in visible light.

Cam Follower. The cam follower and adjusting detail are mounted on the cylindrical end of the flanged mirror shaft as shown on Fig. 7. This mechanism consists of roller 10, roller shaft and nut 11, follower casting 12, shaft adjusting casting 13, tension

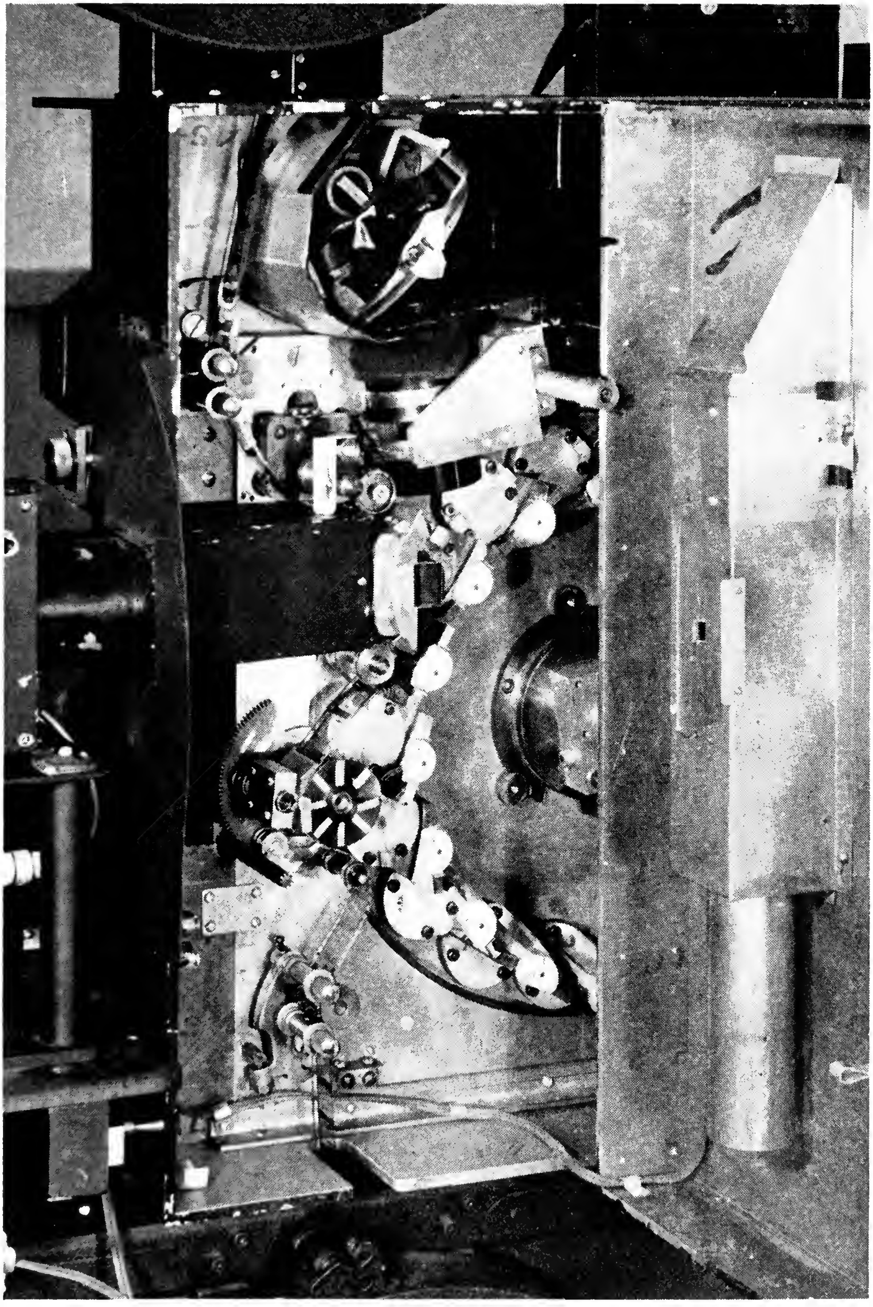


Fig. 5. Photograph of mechanism showing moving mirror drum.

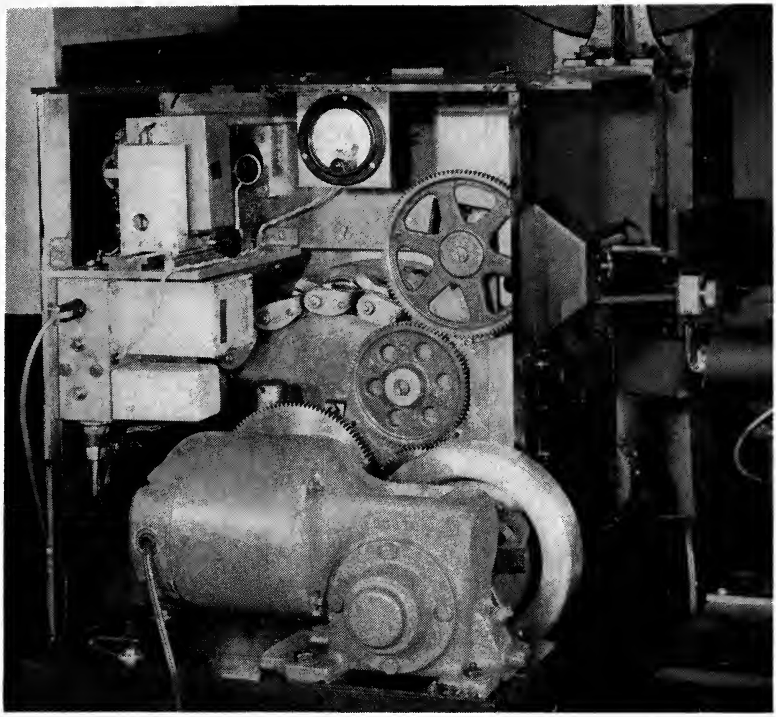


Fig. 6. Photograph of mechanism showing stationary cam and cam followers.

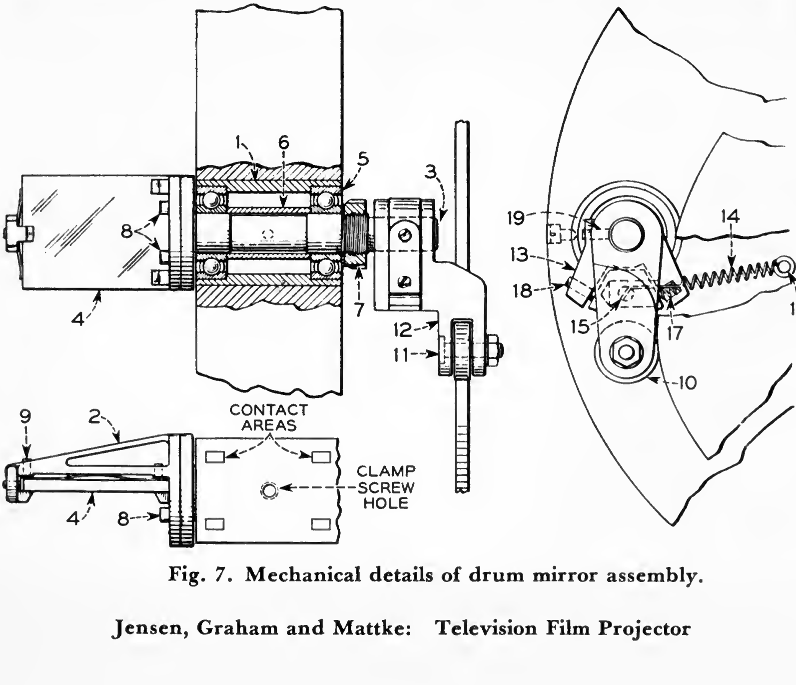


Fig. 7. Mechanical details of drum mirror assembly.

spring 14, spring pin 15, spring stud 16, adjusting pressure spring 17, adjusting screw 18, and setscrew 19.

Spring 14 maintains contact of roller 10 on the cam. Stud 16, to which one end of spring 14 is fastened, is fixed to the body of the drum; the other end of the spring is anchored to the roller casting by pin 15. Spring 17 maintains loading on the adjusting screw 18, which, when turned, changes the angular setting between the follower casting 12 and the mirror shaft 3, thereby allowing the relative mirror angle to be changed.

A photograph of a mirror unit and cam follower is shown in Fig. 8.

Cam. The design of the stationary cam was considered from two requirements: (a) the optical performance of the mirrors and (b) the dynamic balance of the drum. For the optical performance a 40° segment of the cam is all that is necessary. It is this segment that produces the compensation; the remainder is used simply to return the cam follower roller to the beginning of the segment. Dynamically, however, in order to eliminate any unbalance in the rotating system (drum), duplicate cam segments must be located diametrically opposite each other. In this manner the radial distance of opposite mirror mounting castings and associated cam follower mechanisms will always be the same and thereby provide the necessary counterbalance. The final shape of the cam is indicated in Fig. 3 and a portion of the cam may be seen in Fig. 6. A feature of the cam curve is that it can be generated quite easily with a grinding fixture constructed for the purpose. A schematic diagram of the fixture is shown in Fig. 9. In this figure point B represents the axis of rotation of the mirror drum and the circle D represents the location of the axes of rotation of the individual mirrors. Point A corresponds to the point O in Figs. 2 and 4, and point C corresponds to point f in Fig. 4. The fixture consists of two movable arms 1 and 2, interlinked at point E. Arm 1 rotates about point B and arm 2 rotates and slides about point C. The grinder is fixed on arm 2 in such a manner that the center of the grinding wheel is located at point F, where the distance EF is equal to the center-to-center length of the cam follower arm. The diameter of the grinding wheel is equal to the diameter of the cam roller. A photograph of the grinding fixture is shown in Fig. 10.

Position Control

The fundamental principles of operation of this machine were discussed on page 5. If these are fulfilled, if the gears are perfect, without backlash and with correct teeth profile, if the cam has the correct shape and the cam followers are correctly aligned, and above all, if the friction is constant so the film moves at an absolutely uniform rate, then the images on the screen of succeeding film frames will fall exactly on top of each other. The image of each frame will lap dissolve into the image of the previous one without blurring and without loss of registration. In other words, the picture on the screen will be steady without any vertical jitter. Conversely, if the machine is used for film scanning, the image of the scanning raster on the film surface will move in such a manner as to remain stationary with respect to the film frames and no vertical motion or jitter will be observed in the resulting picture on a television receiving tube.*

The present machine does not perform in this perfect manner. It is assumed that the friction in the film drive is not constant, but whatever the cause, the fact is that without any further control, the image moves up and down erratically with a maximum excursion of

* The discussion above relates only to vertical motion of the image. It is assumed that adequate guides in the film drive prevent any sideways weave of the image.

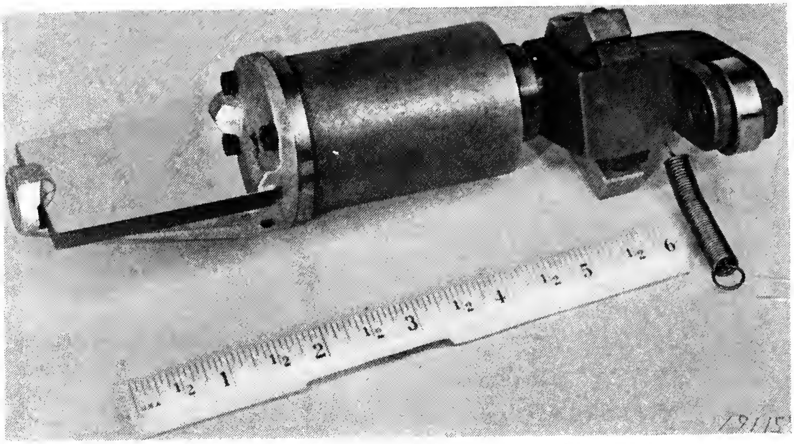


Fig. 8. Photograph of drum mirror assembly.

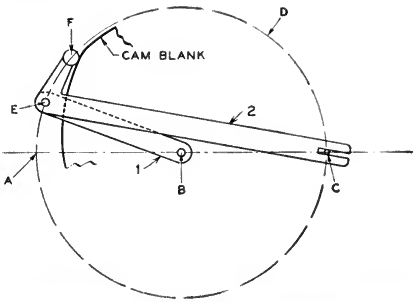
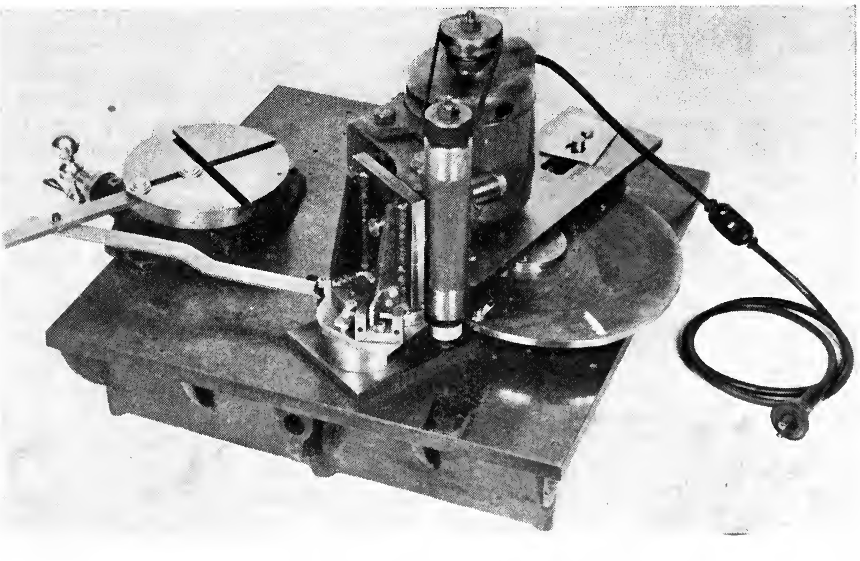


Fig. 9. Diagram of cam grinding jig.

Fig. 10. Photograph of cam grinding jig.



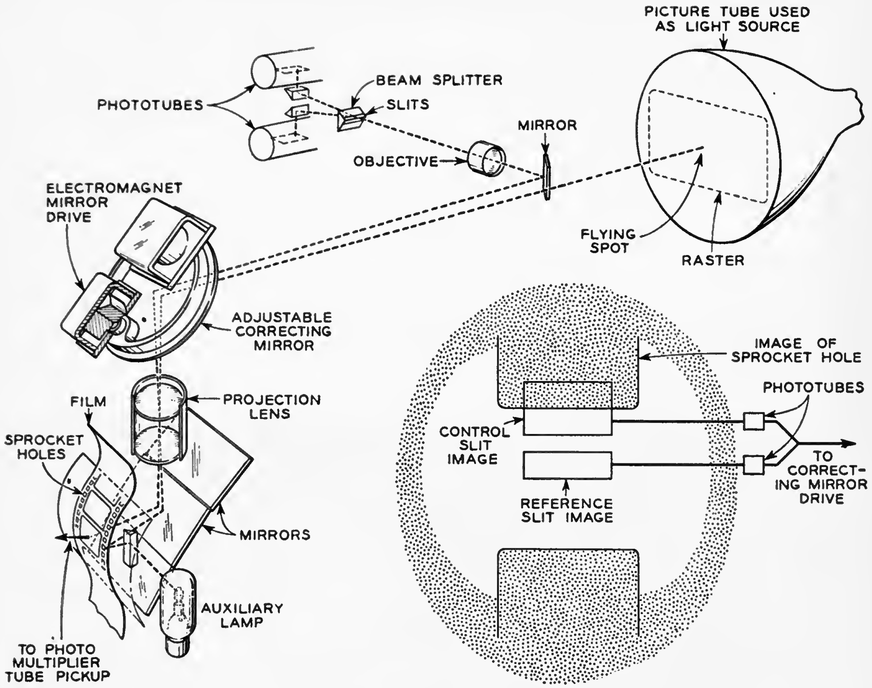


Fig. 11. Schematic diagram of jitter correcting servo system.

about 1/100 of the picture height. This is, of course, disturbing, and would be intolerable in a commercial film scanner. It was decided, therefore, to attempt to eliminate this vertical jitter, not by perfecting the mechanical precision of the component parts, since such perfection would probably require a continuous, time-consuming maintenance effort, but rather by automatically monitoring the departure from uniformity in film motion, and using the indications of such departures to control some element of the system in such a way as to counteract or nullify the vertical jitter.

In the entire processing of motion picture film from camera to projector, the primary standard of registration is the location of the sprocket holes in the film. It is natural, therefore, to use these sprocket holes as a means for measuring the departure from proper motion of the film. Assuming that such "error" information is available, the next question is where to apply it to compensate for the error. In Fig. 3 there is shown a fixed mirror for deflecting the light from the projection lens onto the viewing screen. If this mirror is made adjustable around an axis in the plane of the mirror and perpendicular to the plane of the diagram, then such an adjustment would impart a vertical motion to the image on the screen. In other words, if the "error" signal obtained from monitoring the sprocket-hole position is used to tilt the mirror in such a way as to counteract the error, then the image on the screen will stay still in spite of nonuniform film motion. This is exactly what is done by the jitter-correcting control circuit, or servo, incorporated in the machine, and the

method employed is shown by the schematic diagram in Fig. 11.

This figure shows the essential features of the mechanism used as a film scanner. The light from the raster of the spot scanning tube is transmitted via the correcting mirror through the projection lens, and via the drum mirror through the film onto the cathode of a photomultiplier tube.

An auxiliary light path through the optical system is provided as follows: The sprocket-hole area of the film is illuminated by light from a small incandescent lamp passing through a right-angle prism mounted adjacent to the film gate (see Fig. 11). As far as this sprocket-hole area is concerned the machine now functions as an optical projector. The reflected light from the film surface is passed back through the system as indicated in Fig. 11 and an image of the sprocket-hole area is formed in a vertical plane marked "slits" in the figure. A picture of this image is shown as an insert in Fig. 11. The sprocket holes themselves will appear black in this image, while the film area around the sprocket holes will show uniform illumination.

In this image plane there is placed an opaque mask with two narrow slits as shown in the insert. The lower slit covers part of the film image between two sprocket holes and is used as a reference source, while the upper slit partly overlaps the image of the sprocket-hole edge and is used as a control source. By means of prisms the light from the two slits is passed to two separate photomultiplier tubes and the electrical output from these is passed through a differential amplifier to two electromagnets controlling the position of the correcting mirror.

The system is so adjusted that for the reference position of the image as shown in the diagram the output of the two phototubes is the same. The differential amplifier, therefore, passes no current to the electromagnets and the correcting mirror stays fixed. If, on the other hand, a sudden perturbation in the film motion causes the sprocket hole image to move upwards, then the output of the phototube corresponding to the upper slit will increase. The differential amplifier will then pass a corresponding current to the electromagnets and tilt the correcting mirror in such a direction as to restore the sprocket-hole image and thus the main image to its original position.

It is seen that this electrooptical control system is indeed a servo or feedback system, in that it automatically will tend to keep the "error" signal small at all times. The gain of the electrical part of the system must be high enough to keep residual errors down to a negligible amount, and the frequency bandwidth of the system must be sufficient to make the reaction time short compared to the frequencies of normal perturbations of film motion. In the present system the loop gain is about 50 db at low frequencies and gradually decreases to zero gain at about 250 cycle/sec. A measure of the performance of the system may be had by introducing a sudden electrical disturbance into the circuit. With such a disturbance introduced, the correcting mirror will readjust itself in approximately one millisecond, without any appreciable overshoot.

The mechanical construction of the correcting mirror is shown in Fig. 12. The glass mirror 1 is about $3 \times 4\frac{1}{2}$ in., fashioned from a plano-convex lens with the plane surface polished flat to about one wavelength of visible light. The mirror is cemented to an aluminum frame 2, which in turn is spring supported to the fixed frame 3. The supporting springs are clamped in the fixtures 4. The springs are 0.005 in. thick, 0.03 in. wide and 0.005 in. long between clamping points. The driving electromagnets are shown at 5. The peak-to-peak deflection of the correcting mirror during normal operation is of

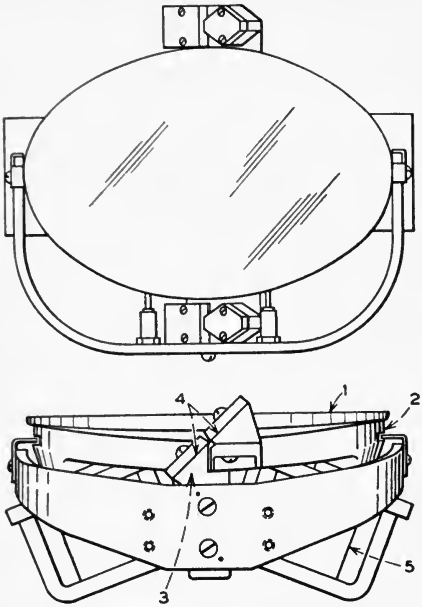


Fig. 12. Mechanical construction of jitter-correcting mirror.

the order of 5 to 10 minutes of arc, and the peak power required to drive the mirror is less than one watt.

The sprocket-hole edge used for control is the trailing edge in the passage through the film drive, since this edge is not subject to gradual deterioration due to drive-sprocket pressure.

It may be asked why the servo system uses light reflected from the film surface, rather than light transmitted through the film. The answer is that the reflection coefficient of the film surface is practically independent of the transparency of the film. If transmitted light were used the control light would be affected by the degree of exposure of the emulsion around the sprocket holes, by surface scratches in the film and, above all, by the fact that some film manufacturers print their firm name at frequent intervals along this part of the film.

In this discussion of the position servo system only nonuniformity of film motion has been mentioned as a source of vertical jitter. Other sources of jitter may be present, such as gear teeth irregularities, cam motion irregularities, optical misalignment, etc. Since the servo system in effect controls the position of the final image, it will tend to minimize vertical jitter due to any of these causes. Even film shrinkage is to some extent compensated for automatically by the servo.

Control of Illumination

As one mirror on the drum approaches the end of its active cycle the light from this mirror will gradually decrease, while the light from the succeeding mirror increases. In an ideal system these opposite changes in light transmission should exactly cancel each other, resulting in constant overall light efficiency throughout the cycle. In the actual machine this is not quite so. An analytical study involving ray tracing through the cycle indicates that for the period when two mirrors are contributing light to the screen there is a small amount of masking of the light falling on one mirror by the edge of the previous mirror. Also during this part of the cycle the projection lens is not entirely filled by light from the two mirrors together.*

The result of this analysis is shown in Fig. 13. It is seen that for about three-quarters (15 degrees) of the active cycle, one mirror, and therefore one film frame, contributes more than 80% to the illumination on the screen. For the remainder of the cycle two adjacent mirrors contribute to the illumination. It is seen that for a small part of this overlapping period the contribution from one mirror (No. 2) falls off faster than the contribution from the next mirror (No. 3) increases. The result

* This study was made on the assumption that the machine was used for optical projections with uniform illumination of the film gate. It is, of course, equally valid when the machine is used as film scanner with a cathode-tube raster of uniform illumination.

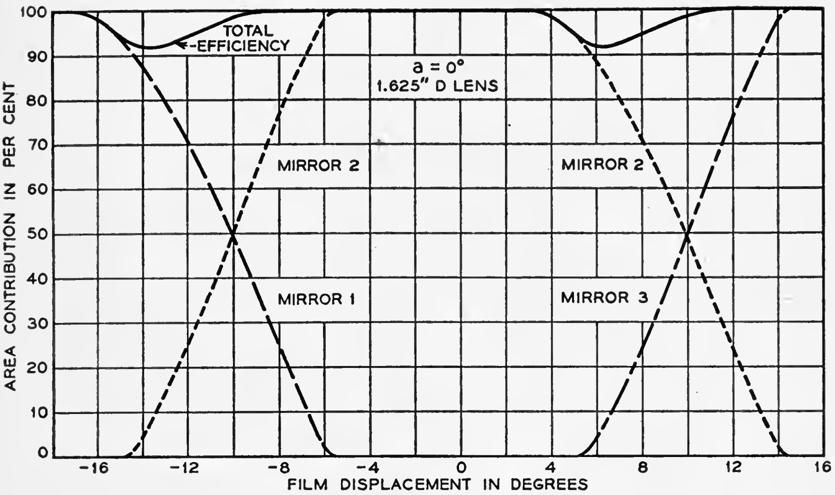


Fig. 13. Variation of light efficiency through mirror compensating cycle.

is a decrease in overall illumination of about 10%, lasting for a small fraction of the active cycle.

The result of this light variation is a certain amount of flicker, scarcely noticeable in the projected image in case of optical projection, but more objectionable in the television image in case of film scanning. In the latter case, low-frequency beats are formed between the 24-cycle film frequency and the 30-cycle television frequency. These low-frequency variations are more disturbing than the small amount of 24-cycle variation present in optical projection. The variation is clearly noticeable when the machine is turned slowly by hand. It manifests itself as a slightly darker horizontal band traveling down the picture as one picture frame fades out and the next fades in.

The analytical study mentioned above indicated that the light variation might be decreased in either of two ways. The edges of the projection lens might be masked off, resulting in lower overall light efficiency, or the number of mirrors on the drum might be increased, resulting in a larger mechanical structure. Since neither method would entirely eliminate the light variation it was decided instead to incorporate in the machine a light-controlling servo system which would compensate for all such cyclic variations in light efficiency.

The principle of this light-servo system is shown in the diagram of Fig. 14, which again shows the principal parts of the machine used as a film scanner. The main light path is from the cathode-ray tube raster through the optical system, through the film in the gate and into the signal photomultiplier. By means of a plane mirror mounted next to the raster an auxiliary light path is provided which also sends light through the optical system, but this light passes through a clear gate at the side of the film gate and from there to an auxiliary photomultiplier. The output from this phototube is then properly biased and impressed on the intensity-control grid of the scanning tube. As long as the light efficiency of the optical system is constant the auxiliary phototube output is constant and is so biased that no control voltage is impressed on the intensity-control grid of the cathode-

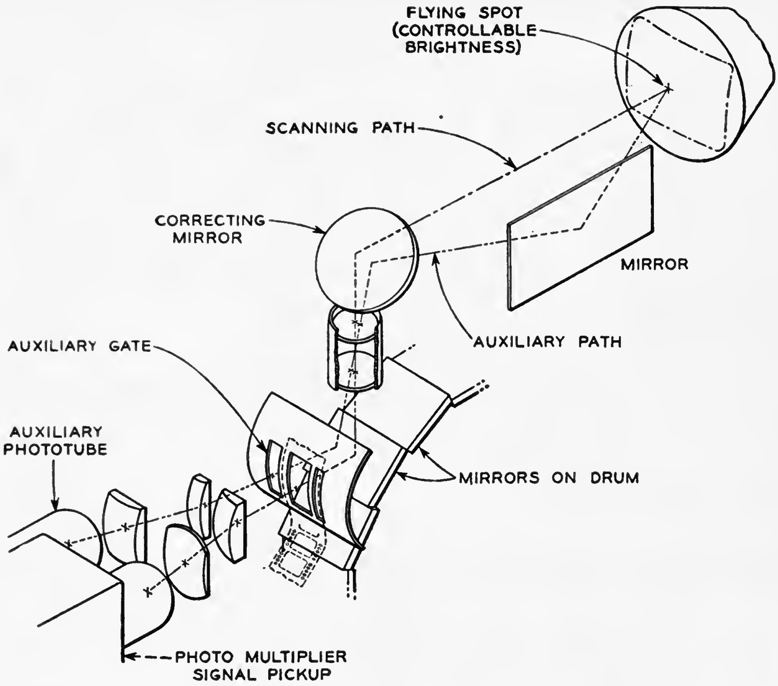


Fig. 14. Simplified schematic diagram of flicker-correcting servo system using separate phototube.

ray tube scanner. If the light efficiency changes, then the corresponding change in phototube output voltage is impressed on the scanning tube grid in such a manner as to restore the illumination of the gate to its original value. Like the position-control system discussed earlier, this light-control system is also a servo or feedback system, which automatically will tend to keep the illumination at the gate constant. The gain and the bandwidth of the electrical part of the system are such that residual light variations are kept to a negligible minimum and that the reaction time of the servo system is fast compared to the periodicity of the light fluctuations in the optical system.

As shown in Fig. 14 the system has the disadvantage of using two photomultipliers, one for the television signal and one for the light-control signal. This requires that any nonuniformities in the photosensitivities over the cathode areas used must be absolutely identical in the two tubes since the illuminated areas on the photocathodes are not the same throughout the cycle. If the variations in cathode sensitivity are different, this will result in a false indication of light efficiency and will actually cause flicker. To avoid this difficulty a modified system was adopted as shown by the diagram in Fig. 15.

In this diagram the drum mirrors and the position-correcting mirror have been left out for the sake of simplicity. Figure 15a shows the spot scanning tube, the projection lens, the film gate and adjacent clear gate or monitoring slit, and finally the common condenser lens and photomultiplier. Figure 15b

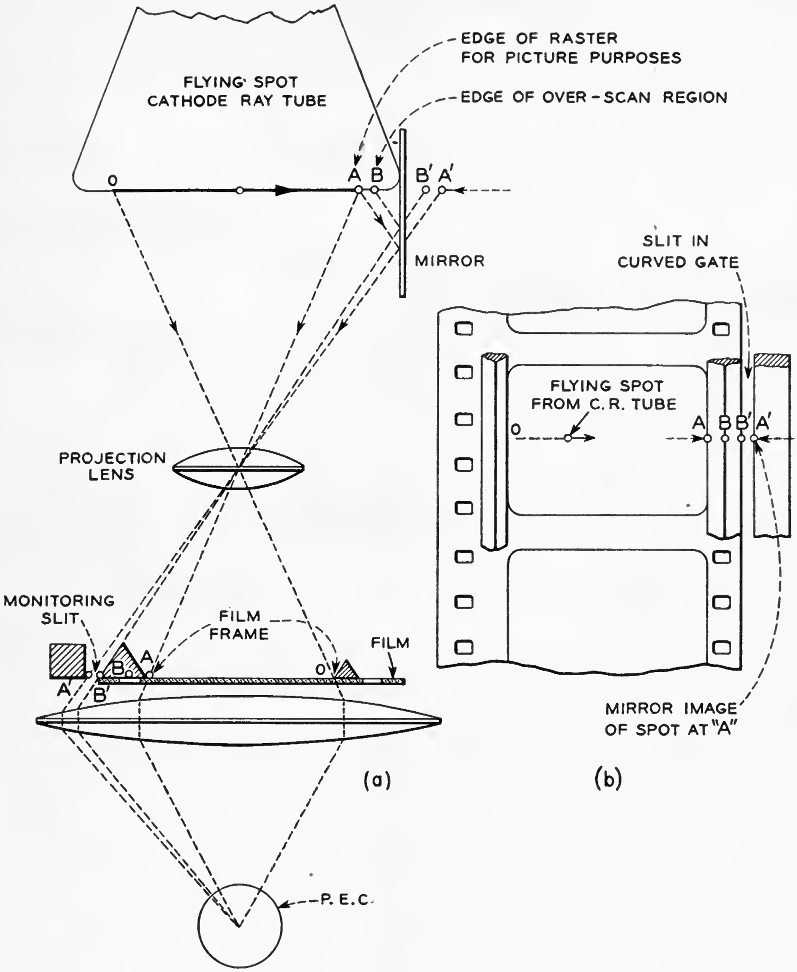


Fig. 15. Schematic diagram of pulse-operated flicker-correcting servo system using signal phototube.

shows a view of the film gate and monitoring slit. As the scanning spot travels horizontally across the tube face from O to A, the image of the spot travels across the film from O to A, the light through the film thus producing the usual television line signal at the output of the phototube. At A the light is cut off by the edge of the film gate. The spot on the tube, however, is allowed to travel a little further until it is blanked off electrically at B. This part of the travel, from A to B, is reflected through the system by a plane mirror in such a manner that the corresponding image travels across the monitoring slit from A′ to B′. The light through the slit passes to the phototube and produces a short pulse immediately following the line signal, the

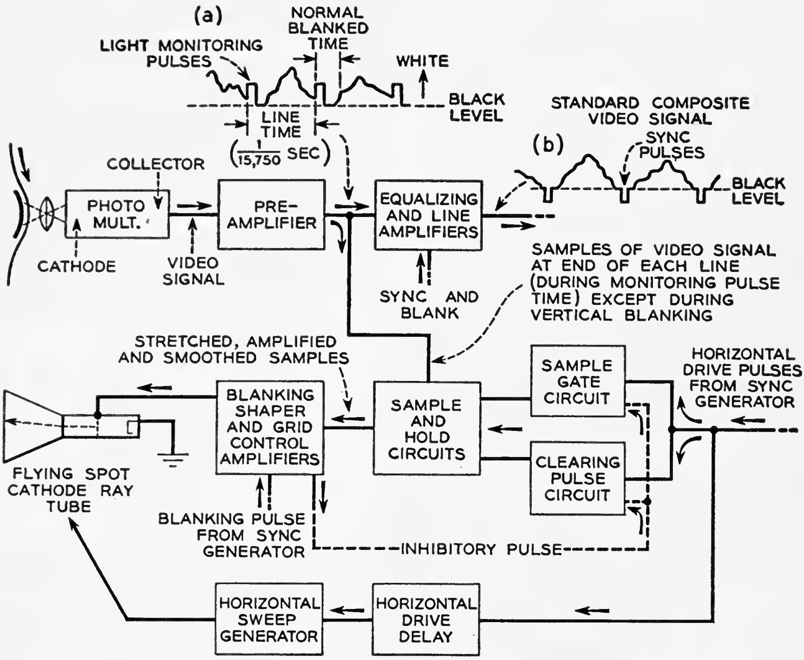


Fig. 16. Block diagram of electrical circuits in flicker servo system.

amplitude of this pulse being a measure of the light intensity in the gate.

The further processing of the photomultiplier signal is shown by the block diagram in Fig. 16. After preamplification the signal appears as shown at a, consisting of a normal line video signal, followed by a short pulse of amplitude proportional to light intensity in the gate. The preamplifier is followed by an equalizing amplifier and a line amplifier, where the light monitoring pulse is blanked out and replaced by standard synchronizing signals supplied by the studio sync generator. The output of the line amplifier is shown at b and consists of a standard composite video signal, ready for transmission.

From the preamplifier the signal also passes to a box marked "sample and hold." In this box the amplitude of the light monitoring pulse is sampled by means of a sample gate circuit and then the sample is "stretched" in time by a holding circuit until it occupies almost the entire time interval until the arrival of the next sample one line later. After some filtering the output of the "hold" box therefore consists of a quasi d-c voltage which is constant in amplitude as long as the gate illumination is unchanged. This d-c voltage is then fed to the grid-control amplifier, which in turn controls the light intensity of the scanning spot. If the gate illumination changes, the monitoring pulse amplitude changes accordingly, thereby changing the d-c holding voltage and the spot intensity in such a manner as to bring the gate illumination back to its original value. Before the control voltage is applied to the cathode-ray tube grid, blanking pulses are inserted to blank off the beam at B in Fig. 15.

Optical Components

The machine is presently designed for scanning black-and-white film. It is possible, therefore, to use on the spot scanning tube a phosphor with the shortest possible decay time, namely, the P16 phosphor, which gives peak light response in the near ultraviolet region. The spot scanner is of conventional design and uses an RCA 5ZP16 tube with an anode voltage of 30 kv. The signal photomultiplier is an RCA 5819 tube with an S_4 photo surface, which is sensitive in the ultraviolet region. The overall spectral response of spot scanner and photomultiplier stretches from about 3500 to 4000 A, with peak response at about 3750 A.

At these short wavelengths it is necessary to pay attention to the transmission losses in the image-forming components, i.e., the condenser lens and the projection lens. The condenser lens is made of quartz and may be assumed, therefore, to have very small transmission loss in the wavelength region used. The projection lens is a modified Kodak Ektar projection lens, 100mm focal length, *f*/3.5. It has been redesigned for the present purpose to work at a magnification of 4:1 and to have best chromatic performance in the region around 3750 A. The glass of the lens measures about 75% transmission at this wavelength. Assuming 10% reflection loss at each mirror surface, we thus have an overall transmission efficiency of $0.9 \times 0.9 \times 0.75 = 0.60$. The lens is stopped down to about *f*/4 and the overall effective speed of the system is thus about *f*/5.

The lamp used for the position control is a 100-w, 110-v tungsten lamp operated at about 60 v and the photomultipliers used for this control are RCA 931A tubes.

Overall Performance

The geometrical resolution obtainable with the machine at present is such as to resolve clearly the bottom of the vertical wedge on the standard RTMA test chart. On pictures of the same RTMA chart all ten strips in the gradation wedges can be clearly distinguished on the face of the monitoring tube. On a 10-in. kinescope contrast ranges over 200 to 1 have been measured from pictorial scenes of the standard SMPTE test film, with adequate gradation in the halftones.

The residual vertical jitter of the picture has an rms value of about 1/2000 of the picture height, or about 1/4 of a scanning-line pitch. The sideways weave of the picture is larger than that, due to the fact that the film is not guided as well as might be desired. It is felt that this weave can be reduced by proper mechanical guiding, but if still better performance is desired, it should be comparatively easy to monitor the edge of the film with a photocell arrangement, and to impart this monitoring signal to a second pair of electromagnets on the correcting mirror.

The signal-to-noise ratio of the video signal from the machine is about 35–40 db, peak signal to rms noise. Undoubtedly this figure can be improved by using a faster lens, maybe an *f*/3 or even an *f*/2 lens. It should be mentioned, however, that a faster lens will have less depth of focus and will be unable to focus the flat tube raster sharply over the curved film frame. With the present lens there is no serious lack of sharpness at the upper and lower edge of the picture. With a much faster lens it would probably be necessary to provide a field-flattening lens to compensate for the film curvature.

Bibliography

1920

C. F. Jenkins, "Continuous motion picture machines," *Trans. SMPE, no. 10:* 97–102, May 1920.

1921

C. F. Jenkins, "Continuous motion pro-

jector for the taking of pictures at high speed," *Trans. SMPE, no. 12:* 126–127, May 1921.

1922

C. F. Jenkins, "Prismatic rings," *Trans. SMPE, no. 14:* 65–71, May 1922; discussion, *ibid.*, 72–73.

F. N. Stewart, "Note on new continuous projector," *Trans. SMPE, no. 14:* 162, May 1922.

1923

H. D. Taylor, "The feasibility of cinema projection from a continuously moving film," *Trans. Opt. Soc., no. 25:* 149–176, May 1923–1924.

1924

L. Bowen and H. Griffin, "Is the continuous projector commercially practical?," *Trans. SMPE, no. 18:* 147–151, May 1924.

1928

A. J. Holman, "A non-intermittent optical projector," *Trans. SMPE, vol. 12, no. 36:* 1184–1188, Sept. 1928; discussion, *ibid.*, 1188–1190.

J. F. Leventhal, "A new optical compensator," *Trans. SMPE, vol. 12, no. 36:* 1068–1072, Sept. 1928; discussion, *ibid.*, pp. 1072–1075.

J. F. Leventhal, "Projectors with optical intermittents," *Trans. SMPE, vol. 12, no. 34:* 406–409, Apr. 1928.

"The Mechau projector," *Trans. SMPE, vol. 12, no. 36:* 1193–1195, Sept. 1928.

1930

A. J. Holman, "Apparatus developed to simplify manufacture of lens wheels for continuous projectors," *Jour. SMPE, 14:* 623–635, June 1930.

A. J. Holman, "Prospects for non-intermittent projection," *Mot. Pict. Projectionist, 3:* 9–10, Oct. 1930.

A. J. Holman, "The revolving lens wheel projector," *Jour. SMPE, 15:* 20–38, July 1930.

A. J. Holman, "Why and how of continuous projection," *Mot. Pict. Projectionist, 4:* 25–26, 31, 33–37, Nov. 1930.

F. H. Richardson, "Continuous projection: an inquiry," *Exhibitors Herald-World, 100:* 49–50, July 5, 1930.

1931

A. J. Holman, "Continuous non-intermittent projectors," *Jour. SMPE, 16:* 612–618, May 1931.

M. Huc, "Non-intermittent motion picture projector," *Bull. Soc. Franc. Phot., 18:* 128–136, June 1931. Abstract in *Eastman Monthly Bull., 18:* 17, Jan. 1932.

Carlos Mendizabel Brunet, "New continuous projector shown by inventor," *Mot. Pict. Herald, 103:* sec. 1, 19, May 16, 1931.

"New non-intermittent projector," *Kinemat. Weekly, 174:* 55, Aug. 20, 1931. Abstract in *Eastman Monthly Bull., 18:* 134, Mar. 1932.

W. C. Plank, "Art of continuous cinematography," *Internat. Proj., 1:* 22–23, Nov. 1931; *ibid.*, pp. 9–11, Dec. 1931.

W. C. Plank, "Some interesting properties of continuous projectors," *Jour. SMPE, 16:* 709–718, June 1931.

1932

A. Bourgain, "Non-intermittent projectors," *Technique Cinemat., 13:* 69–76, Feb. 1932. Abstract in *Eastman Monthly Bull., 18:* 337, July 1932.

Plank, W. C., "Inertia in the service of cinematography," *Jour. SMPE, 19:* 565–578, Dec. 1932.

"A portable non-intermittent cine projector," *Jour. SMPE, 18:* 101–106, Jan. 1932.

H. A. Robizek, "Continuous projection by optical compensation," *Internat. Proj., 2:* 14–16, Mar. 1932.

J. L. Spence, "Mechanical advantages of the optical intermittent projector," *Jour. SMPE, 18:* 593–599, May 1932.

F. Tuttle and C. D. Reid, "The problem of motion picture projection from continuously moving film," *J. Opt. Soc. Am., 22:* 39–64, Feb. 1932; Bibliography, *Jour. SMPE, 20:* 3–30, Jan. 1933.

1933

"A new continuous projection attachment just announced by Victor," *Am. Cinematographer, 13:* 20, Mar. 1933.

M. Pirani and R. Rompe, "Uber Kinoprojektion mit kontinuierlick abrollendem Film," (on the projection of continuous film), *Kinotechnik, 15:* 131–132, Apr. 20, 1933.

F. Tuttle, "A non-intermittent high-speed

16-mm camera," *Jour. SMPE, 21:* 474–477, Dec. 1933.

1934

R. H. Cricks, "The non-intermittent: some attempts at continuous projection," *Ideal Kinema, 2:* 40–43, Sept. 13, 1934. Abstract in *Eastman Monthly Bull., 21:* 161, May 1935.

1937

Fernseh-Filmabtastgerät, "Television film scanning device," *Mechau Filmtechnik, 13:* 163–164, Oct. 1937.

1938

H. S. Bamford, "Non-intermittent projector for television film transmission," *Jour. SMPE, 31:* 453–461, Nov. 1938.

1940

F. Ehrenhaft and F. G. Back, "Non-intermittent motion picture projector," *Jour. SMPE, 34:* 223–230, Feb. 1940.

1944

R. H. Cricks, "The requirements of modern projector design," Bibliography, *Jour. SMPE, 43:* 129–147, Aug. 1944; discussion, *ibid.*, 147–148.

Discussion

Anon: I am sure we all agree that you have done a wonderful job . . . . I'm wondering if you feel that you have sold yourself down the river at all in utilizing the sprocket hole instead of trying to use the frameline on the film in some way?

A. G. Jensen: We felt that the sprocket hole, as far as we understand it, is the primary standard that you have in the motion picture. The whole registration all through the processing is done by means of these sprocket holes, so we felt that they were the primary standard and we were afraid we couldn't hope to do much better than that. If you go by the frame then you are in trouble, because depending upon the film material you don't always have a good reference. You might have to make an artificial reference in order to make sure that you always have a good reference edge — a nice black-to-white edge which will not vary with the content of the picture. When you go by the sprocket hole you don't have that at all. Another thing — it is very difficult, I think, to do a good job of monitoring if you use transmitted light. If you were to use a film frame you would almost be forced to use transmitted light and depend upon black vs. clear film, as I see it. By using the sprocket hole we use reflected light and that seems to be practically independent of what has happened to the film as far as exposure is concerned. Whether the area around the sprocket hole is clear film or completely black exposed film doesn't matter at all. The reflected light is almost independent of that, which is a great advantage. If you were using transmitted light the gain of your servo, the dependability of your servo would depend on the density of the film at the point where you measure. We have avoided that by using reflected light.

Anon: Are you of the opinion that you could use old film and new film and the results would be about the same? The trouble with a lot of television operations is that the prints aren't always good.

Mr. Jensen: Of course I might say that the edge of the sprocket hole that we monitor on is a trailing edge, the one that is least chewed up by sprockets.

John Kudar: Mr. Jensen, a few months ago, I think in *Electronics*, there was an article about this projector and there was a remark that the jitter control would be able to compensate for shrinkage.

Mr. Jensen: Well, it is true that if the shrinkage is not too bad it does do a fairly good job of compensating. If the shrinkage is severe then you do have to adjust the gate, but it isn't too complicated to do. The shrinkage would generally be uniform enough through an entire piece of film so that you don't have to adjust while you're running, but if the film is badly shrunk you may have to adjust initially before you start that piece of film by moving the gate a little bit closer or a little bit further away from the mirrors.

Color Television Reproducers

By HARRY R. LUBCKE

Altering the velocity of traverse of the electron stream in combination with a suitable heterogeneous reproducing screen is the basis of a device described. It differs from the CBS mechanical, the RCA tricolor tube and the Geer screen systems of color television reproducers.

ACHIEVING the right combination of elements for the reproduction of color television is not easy. By counting the issued patents concerned with this problem and observing the accelerated rate at which these are issuing we must conclude that many are now engaged in such research—from the individual inventor to the lush corporate laboratory working around the clock.

One of Zworykin's original patents[1] on the iconoscope, filed in 1925 and now expired, disclosed the elemental type of color screen that is being reinvented to the present day. Another example is due to Bronwell[2] of Chicago. Three grids are provided for a three-color system, arranged in lieu of the fluorescent screen. The wires of one screen are staggered with respect to the wires of the others as regards electron flow. By the expedient of raising the voltage on the grid that carries the color phosphor to be energized at a given instant, the electrons are attracted to it in preference to the other grids and impinge upon it with sufficient velocity to fluoresce the phosphor on that grid alone.

The first all-electronic color television reproducer to be produced in any quantity is the well-known tricolor tube of the Radio Corporation of America. This tube is an improvement of the original obturating principle of the German corporation "Fernseh Aktiengesellschaft" (translated: "Television Corporation") proposed in their French Patent No. 866,065, filed in July 1939.

Fernseh showed rods disposed in only one direction, like pickets on a fence. These were in front of a lined triphosphor screen. RCA did one better than this, by stamping a plate full of holes and arranging three dots of different phosphors behind each hole on the side near the viewer.

Still another scheme is the Geer screen.[3] This was a fundamental invention. It reproduces a color image upon a substantially single plane while retaining necessary uniqueness of rendition of the color components that form the image.

The practical importance of the single-color image has become apparent as the art has progressed. The science of

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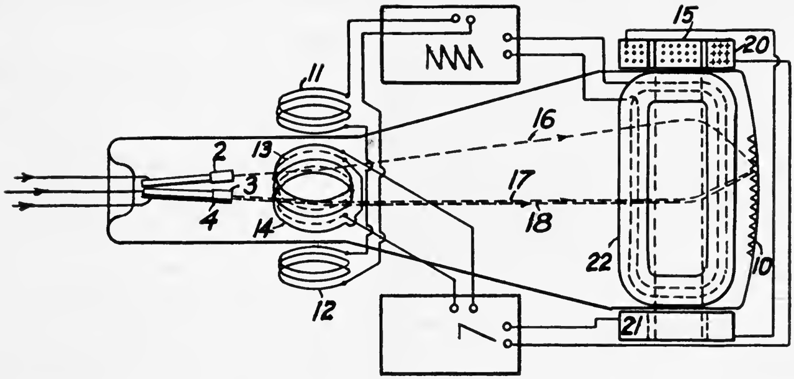

Fig. 1. A three-gun faceted-screen color television reproducing device. The divergently formed electron streams are converged at the screen by the coil assembly.

optics has taught long enough how to combine three-color component images into the full-color composite, but it is inadvisable to leave the matter of registration to the cabinetmaker and the serviceman if there is a better way. The Geer screen allows combination of the colors in proper registration without complicating the electron optics of the device *at the screen proper*.

The tube of Geer and of his contemporaries, A. N. Goldsmith[4] and the late John Logie Baird[5] of England, suffers from the need for (usually) double keystone correction. This is occasioned because of the considerable physical separation of the three electron guns of the devices. If there was a way in which this separation could be eliminated a great improvement would result.

The author evolved an answer to this[6] in the form of a cluster of three guns that originate mutually divergent electron streams at essentially one point. This arrangement is shown in Fig. 1 as guns 2, 3 and 4. The electron streams from these are deflected as a whole by a single set of deflection coils—11, 12, 13 and 14. This arrangement has the advantage of simplicity and accuracy, making it unnecessary to match three pairs of deflection coils for congruence of scanning deflection as is required in the devices previously mentioned.

The new originating arrangement operates with the tridirectional faceted (Geer) screen because of coil 15. Located near the screen and carrying a direct current, it acts to converge the three divergent electron streams 16, 17 and 18 because of radial components of the magnetic field created. By adjusting the current in the coil the three streams are made to converge in the plane of screen 10. In this way, three separate electron streams, independently controllable as to intensity, can be converged at the screen as though each had come from a gun widely separated from the others and each phosphor upon the screen can be individually excited to any degree.

The author has found that this arrangement operates over a considerable area of the fluorescent screen, but not at the extremes. This can be taken care of in two ways.

Firstly, the size of the coil 15 can be increased. One of the advantages of this system is that the deflecting and converging instrumentalities are exterior to the vacuum structure and so can be altered, adjusted or replaced without

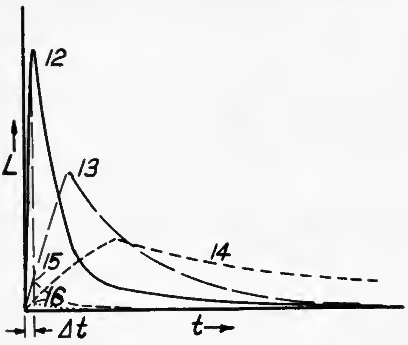

Fig. 2. The rise and decay of light output of three phosphors as a function of time; the basis of operation of cathode-ray-tube color reproducer devoid of geometrical screen structure.

affecting the most costly component, the cathode-ray tube itself.

Secondly, the magnetic axis of the coil can be inclined in synchronism with the scanning of the combined electron streams. In the figure, the two lower streams are at 120° from each other and from the upper stream. The common axis is thus inclined upward at the instant in scanning for which the figure was drawn. Coils 20 and 21 are provided to accomplish the inclination. These are wound in horizontal planes and supplied with a fraction of the vertical scanning energy. The field from these coils alters the original field, reinforcing it below, weakening it above, so that the magnetic axis is above the geometrical axis of coil 15.

With coil 22 and a companion 23 behind, the magnetic axis is also altered from left to right upon the face of the tube. Most fortunately, the converging action is constant over quite an area around the axis and precision in altering the magnetic field is not required.

After considerable further study of this subject the author evolved another method.[7] This method does away with the faceted screen, the magnetic coils and any other physical feature that would identify it as a color cathode-ray tube. The chromatic action takes place in the screen itself.

Man now knows of some two hundred chemical compounds, which, when combined with minute amounts of suitable impurities, give off cold light in return for the energy of impact of electrons. These substances are known as phosphors. By energizing suitable phosphors differently with respect to time, selective excitation of different color components of a heterogeneously constituted screen can be accomplished.

In Fig. 2, for example, curve 12 represents the excitation and decay time of zinc sulfide with a small amount of silver as the impurity-activator, the phosphor being hexagonally crystallized. It will be noted that the response and decay are rapid. This phosphor fluoresces blue.

Curve 13 is for zinc silicate, with manganous oxide as activator, rhombohedrally crystallized. The response and decay of this phosphor are average and it fluoresces green.

Curve 14 is for zinc sulfate, with manganese sulfate activator, orthorhombohedrally crystallized. The response and decay of this phosphor are slow. It fluoresces red.

For any small interval of time, such as Δt shown, the variation of response of the three phosphors is very different, even though each phosphor be impacted with the same number of electrons accelerated through the same potential in the electron gun or guns.

The response of light, L, is near maximum for the rapid phosphor 12. It is much less for the medium phosphor 13, with only the small area under the resulting (dashed) decay curve being effective in light output. The response is even less for the slow phosphor 14, the amplitude rising only to point 16.

Thus, if we traverse our heterogeneous phosphor screen rapidly we secure a nearly pure blue response. But what happens if we traverse such a screen

slowly; do all the phosphors light up and produce white light?

This would be true if the only property utilized was speed of phosphor response. Actually, by combining a number of processes in an additive manner it is possible to shut off the rapid phosphors.

Phosphor materials behave differently under different temperature conditions. It is possible to select particular phosphors and to give attention during the preparation of them so that, for instance, the temperature characteristic of the above-mentioned fast phosphor is such that the light output for a given excitation reduces rapidly with increase in temperature. At the temperature of boiling water the light emitted can be made only one-fifth that at room temperature.

In the present device this phosphor is, furthermore, formed in small particles—less than 10^{-3} millimeter. Small particles heat much more rapidly and attain a higher temperature than large ones. Consequently, the temperature effect is accentuated and under a slowly moving or stationary electron stream, such as is required to activate the slow phosphor; the light from the rapid phosphor has reduced to a small value.

The coefficient of secondary emission of the phosphor is similarly utilized. The coefficient of the above-selected fast phosphor decreases with increase in temperature. By selecting a proper operating potential for the gun of the cathode-ray tube in relation to the secondary emission characteristic of the phosphor the ratio of secondary emission can be made less than one. This means that the phosphor particle accumulates a negative charge under the influence of the slowly moving or stationary electron stream and ceases to glow because of the resulting lower effective velocity of impact.

Not only can these factors, inherent in the rapid phosphor and its preparation, be utilized to cause the blue light to cease shortly after time Δt when the rate of traverse of the electron stream is slower, but the rapid phosphor can be covered with a thin layer of silica, chemically deposited on the particles before the screen is fabricated. Silica has a secondary emission ratio less than one at desirable cathode-ray tube operating voltages. Metals, such as thin films of tungsten, have similar effects. These substances do not appreciably alter the effectiveness of the primary electrons of the electron stream when this impacts the phosphor during the proper brief interval of excitation.

Without going into detail, the phosphor of medium time of response is also formed in small crystals and is chosen and/or treated to cease functioning during slow traverses. It does not, of course, become appreciably excited during the rapid traverses. Should the green signal be black at any particular instant the grid of the electron gun cuts off the stream during the moderate speed of traverse.

The slow phosphor, in addition to its slow response, was selected to perform under the conditions that shut off the more rapid phosphors. It is formed of relatively large crystals that take longer to heat and of a phosphor composition that has a temperature characteristic giving visual response at high temperature and being capable of operating under slow or stationary electron streams for the brief instants utilized in the device.

These characteristics are accentuated in an alternate screen construction that includes a largely transparent, yet "black-screen" metal deposit on the inside of the glass face. This is connected to the second anode. The slow phosphor is laid down in contact with the metal. This removes any possibility of accumulating a negative charge and also provides some measure of thermal sink, preventing heating of that phosphor. The two other phosphors are deposited on top of the slow one and out of contact with the metal coating.

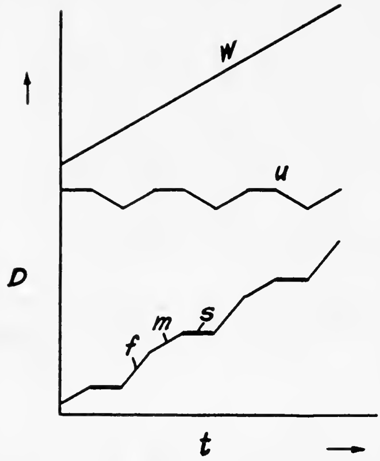

Fig. 3. Incremental waveform *u* is combined with horizontal deflection waveform *W* to secure variation of the velocity of traverse of the electron stream over the phosphors.

Experimentally, the relative amounts of each phosphor may be changed to effect chromatic adjustment. The integrated intensity of the corresponding color is thus varied. The spectral response is empirically determined, being composed of the inherent response of the phosphor and a small and fixed response of another. Not every batch of available phosphors can be used with certainty. Because the impurities of subspectroscopic amounts and the actual lattices formed vary with ingredients and the precise routine of preparing the phosphor, variation of performance will be experienced unless the phosphor used is selected upon the basis of test under operating conditions.

Fast, medium and slow traverses of the electron stream over the phosphors have been mentioned. In monochrome television the scanning speed is constant over all of the visible portion of the reproduction. In the present device a high-frequency deflecting waveshape is combined with the usual horizontal deflecting waveshape to accomplish speed variation. For a three-color system, a truncated triangular wave is one shape that is used; that is, a triangular wave-shape with the tops of the triangles cut off.

This is shown in Fig. 3. Waveshape *W* represents a small portion of one horizontal scan. Displacement *D* across the field of view is represented vertically and time horizontally as the abscissa. Waveform *u* is the truncated triangular one. When these two are combined the third waveform results. Where the slopes of waveforms *u* and *W* are the same, the resulting velocity is greatest, as at *f*. When waveform *u* effects no displacement with time, the top truncated portion, the resulting velocity is medium, as at *m*. Where the slopes of waveforms *u* and *W* are equal but opposite, the resulting velocity is zero, as at *s*. Thus, the scanning spot successively travels rapidly, at medium speed and stops, all at substantially dot repetition rate.

Refinements are possible; an asymmetric truncated waveshape can be produced by attenuating the low-frequency response of the truncated wave device. The slanting truncated top then produces the stationary spot, the rapid traverse is then more rapid and the normal or medium traverse is actually executed in reverse. Also, the stiffness of the electron stream can be altered in synchronism with these incremental deflections and the ratio of velocities further increased.

Two types of devices to provide the truncated waveshape have been developed and tested. One is a resonant oscillatory circuit employing a single small triode. Two of the coils of that circuit are placed astride the neck of the cathode-ray tube and directly deflect the electron stream in the desired waveshape. The other type of device is a relaxation oscillator that gives a triangular waveshape directly. This is truncated with a diode. The resulting

wave is fed into the usual horizontal deflecting coils, into similar coils of a few turns or impressed upon deflection plates within the cathode-ray tube.

The period of each of the three portions of the truncated wave is made equal to the period of exhibition of one of the primary colors of the color system. The above-described oscillator is kept in synchronism by feeding a small amount of color change information to it.

The color image thus formed is composed of a short blue dash, a shorter green dash and a red dot successively repeated along each line of scanning in approximately the same manner as the individual primaries are reproduced side by side in the shadow mask tricolor tube.

Other phosphor combinations have been worked out so that the dot is of green rather than red hue to favor rendition of detail. Several relations between detail and color standard are possible.

Acknowledgment

The encouragement given to this work by Willet H. Brown, President of the Don Lee Broadcasting System, Hollywood, is gratefully acknowledged.

References

1. V. K. Zworykin, U.S. Pat. 1,691,324, Nov. 13, 1928.
2. Bronwell, U.S. Pat. 2,461,515, Feb. 15, 1949.
3. C. W. Geer, U.S. Pat. 2,480,848, Sept. 6, 1949.
4. A. N. Goldsmith, U.S. Pat. 2,481,839, Sept. 13, 1949.
5. John Logie Baird, British Pat. 562,168, application dated July 25, 1942.
6. U.S. Pat. application, CCRT I.
7. U.S. Pat. application, CCRT III.

Film-Spool Drive With Torque Motors

By A. L. HOLCOMB

The characteristics of torque-motor drives are described in connection with their use for take-up and feed spools in film-pulling mechanisms. A useful but limited field of application for this type of drive appears to be indicated.

In recent years torque motors have been successfully used in some applications as a drive for take-up spools replacing the older friction-drive devices, and it is the purpose of this paper to consider the relative merits of both methods with respect to performance and convenience. The term "film spool" is here used to cover all of the various types of reels and similar devices on which film or tape is wound or from which it is unwound in the process of recording or reproducing sound.

A "torque" motor is any motor which produces maximum torque at standstill and which provides a sufficiently high input impedance to allow it to be stalled without excessive current demand. Such motors may be either a-c or d-c and are usually rated on the basis of stalled torque and the percentage of operating time they may be stalled without exceeding some acceptable temperature rise. The type most used is an a-c induction motor with either three-phase or single-phase stator and equipped with a high-resistance rotor. The development of compact a-c capacitors has permitted the use of two-phase stator windings, one of which can be effectively resonated with a series capacitor, thus providing the necessary phase shift for operation from a single-phase source. Such "capacitor run" motors are more easily switched and controlled than three-phase motors and provide essentially the same operating features.

The use of torque motors as a take-up drive for film-recording equipment was experimentally considered as long ago as 1935. The motors then available for such duty were three-phase, wound rotor units and series d-c or universal-type motors. While it was found possible to operate such motors so as to provide an approach to constant film tension, it was decided at that time that the advantage realized did not justify the cost and circuit complications which were found necessary. Torque motors have been used with excellent results in many of the magnetic-tape recorders developed in recent years, and it has logically been suggested that

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the modern version of these motors would be of value in sprocket-type recorders and reproducers using 35mm, $17\frac{1}{2}$mm or 16mm films.

Film and Tape versus Flutter

Standard $\frac{1}{4}$-in. tape as now used employs a thin flexible base which conforms readily to small-diameter drums or capstans, permitting such units to operate at relatively high speeds. The base is too fragile and flexible to utilize sprockets and sprocket holes as a synchronizing means and, consequently, a friction drive to the capstan is satisfactory. Thus, without gears or sprockets, good motion can be obtained with a relatively simple mechanical filter provided the drag and take-up are smooth. Torque motors provide not only a smooth drag and take-up, but also a convenient high-speed drive in either direction which is an essential facility in most tape machines.

Motion picture film base is relatively thick and provides sufficient longitudinal rigidity and durability to withstand not only the constant small synchronizing impulses imparted by normal sprocket action, but also the high acceleration of intermittent picture motion. Synchronism between films is obtained by effectively gearing the film to the sprocket, the sprocket to the drive motor, and electrically gearing the motor to similar motors or to a common supply line. All of these gear trains present in some degree the characteristics of inertia, resilience or backlash, and the resultant unfiltered film motion is far from desirable by sound-recording standards. Thus, the mechanical filter requirements are obviously more exacting for sprocket-type film machines than for tape machines. Uneven or erratic take-up or drag can add to the total "flutter" or "wow" which must be corrected and it was one of the objects of this investigation to determine whether the substitution of torque motors as a drive for the feed and take-up spools could provide measurably better film motion than the friction-type drive when operated in conjunction with a good mechanical filter.

The flutter which may be contributed by feed or take-up spools may take any or all of four forms:

1. Low-frequency or erratic variations due to uneven friction in clutch or belt drive.
2. Sprocket-hole flutter (96 cycle/sec) due to high film tension at beginning or end of a reel.
3. Erratic shifting of the film with respect to the sprockets at "crossover" where the net tension on the film reverses.
4. Gear-train chatter due to unloading the sprocket gears at crossover.

It will later be shown that the friction drive may contribute 1, 2 and 3, but not 4, and while the torque-motor drive is not likely to contribute 1, it may contribute 2, 3 and 4.

In order to visualize the conditions existing during the transfer of a standard 1000-ft reel of film from feed to take-up spools, it may be worth while to consider some of the factors common to a constant-torque drive.

Film Tension — Constant Torque

The minimum safe take-up tension is determined by loop formation at start and is about 300 g, although somewhat less than this value may be operable. The maximum tension is determined by film breakage or sprocket-hole mutilation and is dependent to a large extent on the film path, matching of sprocket teeth and sprocket holes, the size of drive sprockets and the acceleration characteristics of the driving system. It can be stated, however, that in general the maximum tension should never exceed 2500 g. Drag tension need only be enough to prevent a full reel from coasting and 150 g minimum is satisfactory.

A standard 1000-ft reel presents approximately a 2-in. diameter spool when empty and $9\frac{7}{8}$-in. diameter when

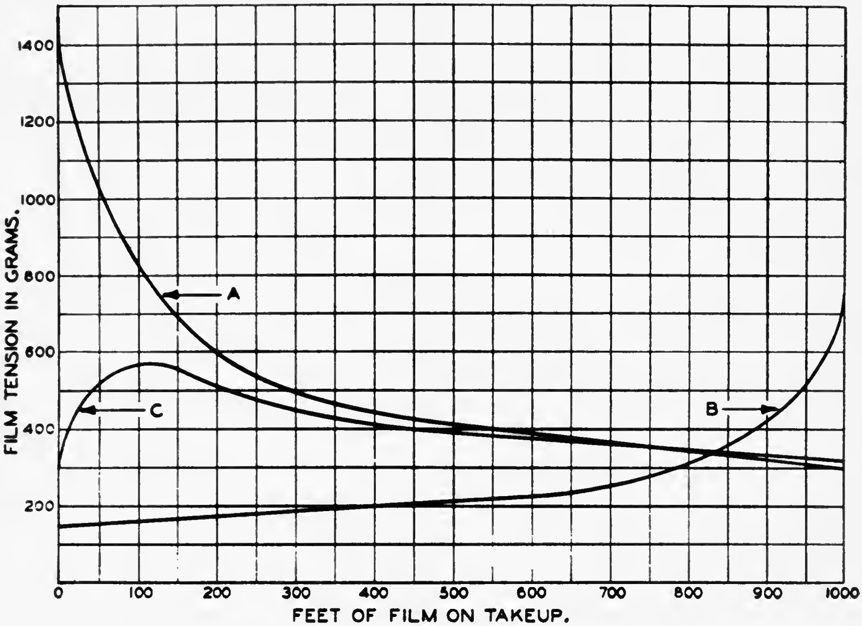

Fig. 1. Take-up and torque-motor characteristics; tension vs. feet of film on take-up.

full. Since the film speed is fixed at close to 90 ft/min, the reel speed must vary inversely with the effective diameter of the spool on which it is wound or from which it is unwound. The speed of a 1000-ft take-up reel at start is thus about 172 rpm and at the end of a 1000-ft roll is roughly 35 rpm, the feed-reel speed varying in the same manner, but inversely.

A good friction clutch, as used for this duty, delivers essentially the same torque to the driven element regardless of the differential or slip speed between driver and driven members. If the diameter of the film spool were constant, this constant torque would produce a constant pull, or tension, on the film, but the spool diameter varies from 2 in. to $9\frac{7}{8}$ in., or a ratio of 4.9:1, and as a result the tension varies by the same ratio. If the torque is expressed in gram-inches (grams pull on a 1-in. radius), and this factor is constant, then the film tension under any spool condition will equal the torque divided by the spool radius.

The film-tension conditions for a 1000-ft take-up reel (curve A) and feed reel (curve B) with 2-in. hubs are shown in Fig. 1, plotted against the number of feet of film accumulated on the take-up reel. Since the minimum take-up tension of 300 g is desired, it is assumed that the friction of the take-up clutch has been adjusted so that this tension is obtained with a full reel (radius 4.94 in.), and the torque which will remain constant is then 1480 g-in. ($300 \times 4.94 = 1480$). The minimum spool radius of 1 in. increases the tension to 1480 g. It will be noted that reel speed and film tension are directly related and both are inverse functions of spool radius. Thus, the two curves showing film tension from the feed reel, B, and from the take-up reel, A, are similar, but reversed. The minimum drag tension, as shown, is set at 150 g. It will be apparent that most of the

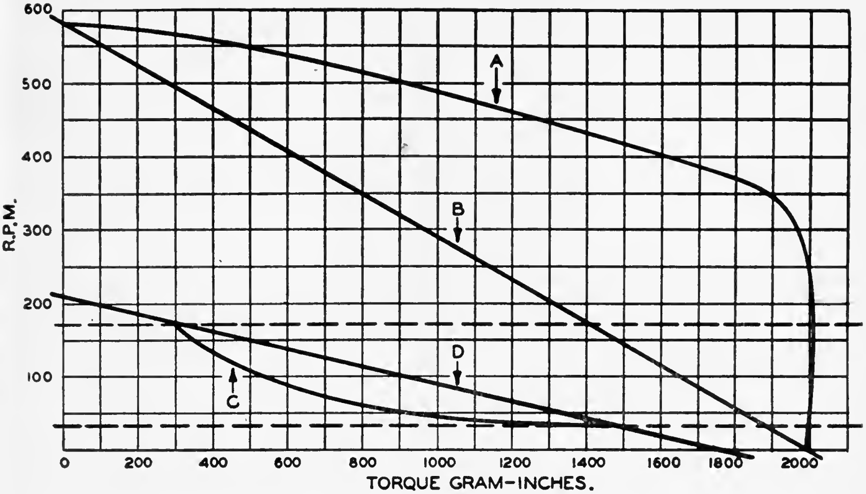

Fig. 2. Take-up and torque-motor characteristics; speed (rpm) vs. torque.

tension change occurs when the hub radius approaches minimum, and demonstrates that the use of reels with 4-in. diameter or larger hubs would materially reduce the tension ratio. Curve C of Fig. 1 will be referred to later in connection with Fig. 2.

It has generally been accepted that 2000-ft and larger reels present a more difficult take-up problem than the standard 1000-ft reel with a 2-in. hub. This is true only with respect to inertia since 5-in. hubs are generally used on the larger reels and the ratio of minimum and maximum diameters and film tensions is more favorable for such reels up to 6000 ft (ratio 4.8:1) than is the case in 1000-ft reels. The inertia, however, increases approximately as the 4th power of the film-spool diameter and, consequently, the torque required to prevent loop formation at start becomes excessive except as a smooth and slow-starting drive system is employed.

"Crossover" occurs in the region where the drag tension equals and then exceeds the take-up tension and due to the high-tension ratio (nearly 5:1) of a 2-in. hub, this condition cannot be avoided with a constant-torque drive.

With well-matched sprocket teeth and sprocket holes and a film path which provides a considerable belt effect between the film and the body of the sprocket, the film motion, with respect to the sprocket, suffers very little due to the change in direction of the net tension; but a flutter condition can exist due to gear chatter if the crossover removes the load from the sprocket-driving gears and drive motor. This condition can occur with torque motors, but when a friction-clutch take-up is driven from the sprocket shaft it is usual to provide an overdrive of about 20% above the maximum reel speed. This presents a friction load on the gear train and motor at all times, regardless of tension between the take-up reel and sprocket, which is in the same direction as the drag from the feed reel. Thus, a friction-clutch take-up will normally present a film tension crossover, but if properly designed will not unload or reverse the torque on the take-up sprocket and motor gears. To realize fully this advantage in a dual sprocket drive, the holdback sprocket should also be damped or loaded.

Torque-Speed Characteristics

Figure 2 shows torque-motor characteristics at A and B, and at C shows the ideal torque-speed curve required to provide constant film tension from a 1000-ft reel with 2-in. hub. Curve A shows the relation between torque and speed of a 12-pole torque motor frequently used as a direct drive for take-up reels. For take-up duty the speed of the reel and of the torque motor is determined by the film speed, and it will be noted that the dotted lines carried out from the minimum and maximum reel speeds of 35 and 170 rpm both intersect the motor characteristic at about 2000 g-in. Thus, the torque of this unit, as normally used, is constant and behaves in the same manner as does a friction clutch. Ideal torque-motor characteristics shown by the straight line B, drawn from stall torque to free speed, would be some improvement but would still fall far short of matching the curve C.

The stall-torque or zero-speed point of either A or B can be moved toward zero torque by various means such as series resistance, but the no-load speed is chiefly a function of the number of poles in the motor and, thus, it becomes apparent that even an approximation of curve C will require either a 36-pole motor or approximately a 3:1 mechanical-speed reduction. The characteristic D can be obtained in this manner and while it does not provide constant tension due to the curvature of C, it is an approach thereto, as shown in C of Fig. 1. The latter is replotted from curve D in terms of film tension on a take-up reel driven by a 12-pole torque motor with a 3:1 mechanical reduction, and represents the best relationship that can be obtained between film tension and number of feet of film on the take-up with a torque-motor drive. However, this destroys the ability for fast runback except as a gear change is employed, and spoils the mechanical simplicity which is one of the most attractive features of torque motors for this duty.

Flutter Characteristics

In Fig. 3A the total flutter of a very good tape machine is shown without automatic speed correction and the same record is shown in Fig. 3B with speed correction. The average rms value for either condition is about 0.06 or 0.065%. This relatively low average of total flutter is a good example of what can be done with a simple filter and torque motors when gears and sprockets are eliminated. An attempt was made to produce approximately the same type of drive and filtering action as obtained in the tape machine, but substituting a 16-tooth sprocket as a drive member together with the necessary gears. Torque motors were used for drag and take-up duty and the drum near which the recording head was located carried a substantial flywheel. The resultant flutter from a very good record is shown in Fig. 3C. It will be noted that the average flutter is somewhat greater than that of the tape machine, and shows considerable low-frequency variations and erratic characteristics not present in the tape record. These flutter charts are made on a time axis in which one division equals one minute and in which the vertical ordinates represent 0.01% peak or 0.007% rms flutter for each small division.

The performance shown at C probably represents as good motion as could be obtained from synchronously driven 35-mm film with a mechanical filter such as is used in the best magnetic-tape machines. The take-up and drag tensions on the film machine were adjusted to be the same as shown in Fig. 1. Although 5-in. hubs were used, some evidence of high take-up tension will be noted at the beginning of the reel, although the increase of drag tension at the end of the reel does not reach a

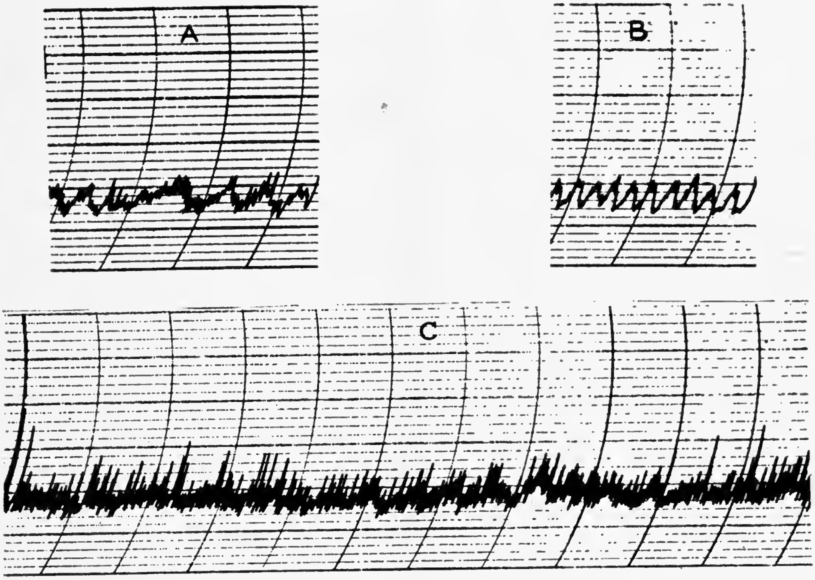

Fig. 3. Flutter characteristics. A and B, tape machine; C, 35mm sprocket machine.

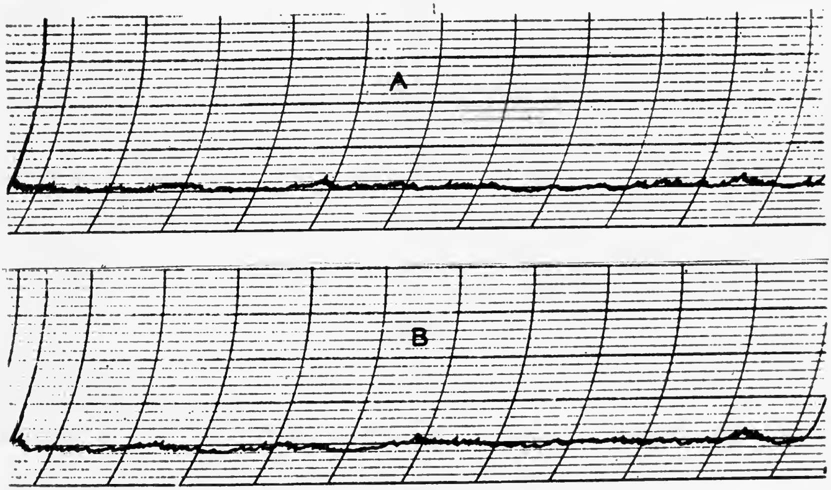

Fig. 4. Flutter characteristics — 35mm sound recorder. A, friction take-up and drag; B, torque-motor take-up and drag.

sufficiently high value to be significant. An increase in the number and amplitude of erratic excursions toward the end of the record shows the effect of crossover.

Figure 4A is a chart made using the same record as in Fig. 3C reproduced on a standard Westrex RA-1467-A Recorder, described by Crane, Frayne and Templin,[1] with sprockets and mechanism as described by Davis.[2] This machine was not given special treatment other than a check to insure normal operation of all elements. In Fig. 4B is shown a similar chart made from the same record on the same machine, but with torque-motor take-up and drag. Within the accuracy of measurement, which is about 0.005%, the two charts are essentially similar, neither one showing any adverse effects from crossover or other take-up disturbances. An analysis of the flutter under the two conditions is practically identical and is shown in Table I, neglecting those frequency bands where the measured values are less than 0.01% rms.

Table I.

Cycles	Per cent rms
1–200	0.035
130–200	0.021
80–130	0.014
50–80	0.010
34–50	0.010
4½–7	0.010
1–2½	0.014
0–1	0.010

Using the torque-motor take-up, a considerable number of tests were made with various values of constant tension and constant torque. The results indicated that with this particular recorder the filter system was adequate to eliminate undesirable effects of crossover or variations in film tension up to about 2000 g. Thus, as far as this production recorder is concerned, it would appear that a good friction-clutch take-up driven by a reasonably smooth belt is capable of delivering essentially the same flutter performance as when equipped with torque motors.

Operational Features

Torque motors, however, do have a number of advantages, for certain specific duties, which the friction drive cannot supply. They are readily operable in both directions by simple switching, at slow speeds for normal recording, or at high speeds for fast rewind in either direction. They are also capable of being controlled to provide constant tension if such control is deemed necessary, and where 1000- and 2000-ft reels are used interchangeably they can be switched to provide the proper torque for either condition. They also have a further advantage, that if they are conservatively engineered for the job so that they do not overheat, there is little, if any, maintenance required. However, torque motors are inherently slow in response, due to a poor torque-inertia ratio, and they should be equipped with electromechanical brakes to prevent coasting and to provide some rigidity of the reels for threading operations when the drive power is off, because when film is allowed to develop appreciable slack, torque motors are likely to break film or tear sprocket holes when the motors are excited and this slack is taken up. Such motors are, in effect, a separate motor system which requires additional controls of some complexity if the desirable features are to be realized. Also, the weight of a pair of these motors, together with the necessary control equipment, will add at least 25 lb to any 35mm machine on which they are installed.

Conclusion

For production recording in which experience indicates that it is seldom necessary to run forward or back at high speeds, it does not appear that torque motors contribute features which justify the added weight, bulk, and

control complication. For re-recording, however, high-speed operation in either direction is a desirable feature and the additional weight and bulk in such stationary equipment is unimportant.

References

1. G. R. Crane, J. G. Frayne and E. W. Templin, "A professional magnetic-recording system for use with 35-, 17½- and 16-mm films," *Jour. SMPTE, 56:* 295–309, Mar. 1951.
2. C. C. Davis, "An improved film-drive filter mechanism," *Jour. SMPE, 46:* 454–464, June 1946.

Discussion

Col. R. H. Ranger: Some time since, we worked on torque motors for tape machines, but I'm very much interested in this application to 35mm. Isn't it true that the reverse characteristic of a torque motor applies only in the direction in which it is trying to drive? In other words, if you use it as the release motor, why, it will not at all have the same characteristics as it does for the take-up. In our work we use a torque motor with a high-resistance rotor for the take-up, but for the release we found that d-c, applied to an ordinary induction motor, gave very much more the characteristics that we wish; in other words, you get a very uniform inverse ratio of torque to diameter with that kind of a setup. Is that not correct?

A. L. Holcomb: The characteristics do vary. However, when we use a 12-pole motor with a characteristic similar to that shown in Fig. 2 (curve A), the torque is essentially the same ± 172 rpm as it is at standstill. As noted in this paper, such a motor is a constant torque device over the range of reel speeds.

Col. Ranger: As it goes through the zero point, the action is entirely different, the curve is practically flat, in the reverse direction. Whereas if you use d-c on the winding of an ordinary induction motor, you get a very nice inverse curve.

Mr. Holcomb: That's true.

Col. Ranger: And it has the decided advantage that it gives you high-speed rewind; and so it gives you, I might almost say, all the things you want.

Mr. Holcomb: That is quite true. You would get a slightly better characteristic with d-c, for drag duty, than you would when reversing the direction of rotation against a-c torque. This difference may well be worth while for tape machines, but for sprocket-type machines, the difference in performance is not apparent.

Col. Ranger: Plus the opportunity to have a d-c brake.

Mr. Holcomb: Yes, a brake appears to be very necessary. For sprocket machines a "normally on" electromechanical brake seems preferable in order to provide some reel stiffness during the threading operation when there may be no electrical excitation.

Heat-Transmitting Mirror

By G. L. DIMMICK and M. E. WIDDOP

Radiant energy incident upon a glass plate can be divided into transmitted and reflected bands by the interference effect in thin films of dielectrics deposited on the glass. The mirror described here reflects over 95% of incident visible light and transmits a large part of the energy beyond 7000 A. Such mirrors have been produced and typical transmission characteristics are shown. Several arrangements for use of such a mirror with a carbon arc are also shown.

The problem of producing "cold light" has occupied the attention of scientists and engineers for many years. A number of methods have been successfully employed for reducing the relative amount of radiant energy which lies outside the visible spectrum. One approach to the problem is to employ a light source which radiates a large portion of its energy in the visible spectrum. The fluorescent lamp and the mercury-vapor lamp are examples of this type of source. Unfortunately, the unit brightness of the fluorescent lamp is too low to have much application in optical systems of the projection type. Fluorescent lamps are, however, used extensively for general lighting where the area of the source can be relatively large. High-pressure mercury-vapor lamps are capable of producing large values of brightness, but they are deficient in red energy, and a large part of their radiation is concentrated in a number of discrete lines. The addition of cadmium vapor into a mercury-vapor lamp greatly improves the distribution of energy in the visible spectrum and makes this type of lamp a potential competitor to the carbon-arc and the incandescent lamp for application in projection-type optical systems.

Another approach to the problem is to employ a carbon-arc or incandescent light source and to remove as much of the infrared energy as possible with the aid of absorption filters or with heat-reflecting mirrors. Absorption filters may be made of special heat-absorbing glass or they may be cells covered on both sides with ordinary glass and having a liquid, such as water, flowing continuously through them. The heat-absorbing glass filters usually require a current of air to flow past the two surfaces to carry away the heat. A well-known type of heat-reflecting mirror is produced by evaporating a thin film of gold onto one surface of a plate of glass. The thickness of the gold may be

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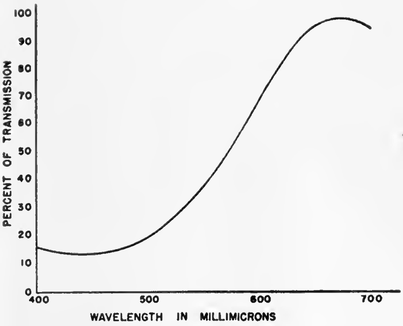


Fig. 1. Transmission curve of a typical dichroic.

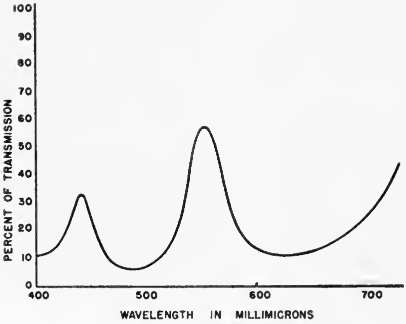


Fig. 2. Transmission curve of dichroic consisting of two sets of layers.

such that its transmission is maximum for green light and its reflectivity is high in the infrared region of the spectrum. Heat-reflecting mirrors of this type have a very limited application because the transmitted light is peaked in the green and the transmitting efficiency is low even at its peak.

Still another approach to the problem is to use the principle of interference in thin films to build up the reflectivity for light within the visible spectrum and to permit the infrared energy to be transmitted. It is toward this solution to the problem that the present paper is directed. The use of multiple films for the production of dichroic mirrors has been covered in the literature and will not be described in detail here. It is sufficient to say that efficient dichroic mirrors may be made by evaporating on glass alternate layers of two transparent dielectric materials, one of which has a relatively high index of refraction while the other has a lower index of refraction. The thickness of each layer is usually made to be $\frac{1}{4}$ wavelength for light of the color which is to be reflected. It is possible to make dichroic mirrors which reflect as much as 95% of the light of one color and transmit 90% or more of the light of another color. A typical curve for a dichroic reflector is shown in Fig. 1. The peak reflection occurs at about 450 mμ while the peak transmission occurs at about 650 mμ.

One of the important characteristics of a dichroic reflector is that the absorption of visible and infrared radiation can be made negligibly small. This means that radiation which is not reflected from the multilayer film is freely transmitted through this film. It was this property which gave the authors the idea for a heat-transmitting mirror which would reflect efficiently only in the visible portion of the spectrum. The idea was to deposit several sets of multilayer dichroic films on the surface of a plate of glass. Each set would be so controlled as to cause its peak reflection to occur at a different wavelength. The peaks would be equally spaced through the visible spectrum so that all portions of this spectrum would be reflected efficiently. Light which did not reflect from the outermost dichroic film would pass through this film to one of the inner films, where it would be reflected and would then pass back through the outer films to the surface.

The first test of the idea was made several years ago in an RCA Advanced Development Laboratory in Indianapolis. Two sets of dichroic films were deposited in succession on the surface of a plate of glass. The thickness of the layers of one set was so controlled

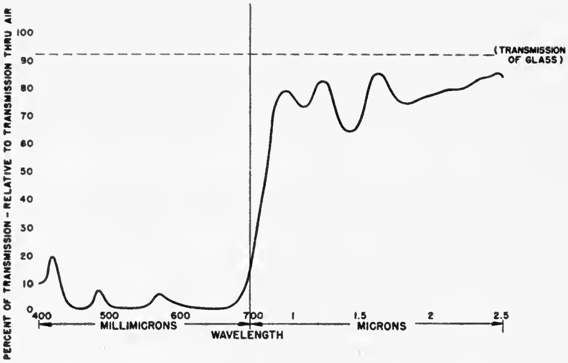


Fig. 3. Transmission characteristics of a heat transmitting mirror.

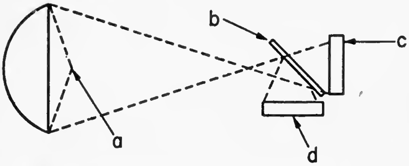


Fig. 4. Setup used for measuring heat transmission and reflection of mirror.

as to make the peak in reflectivity occur at 490 mμ. The other set of layers was made to have its peak in reflectivity at 650 mμ. The transmission curve of the completed mirror is shown in Fig. 2. As expected, a curve with a double hump was produced by the above procedure and the efficiency of the reflector was greatly improved. The results of the first tests were so encouraging as to warrant a systematic study of the different parameters upon which the overall effectiveness of a heat-transmitting mirror is based. Development work on this project continued intermittently for several years. The improvements which were made resulted in mirrors having a degree of reflectivity which is greater than that of a back-silvered glass mirror.

The curve in Fig. 3 shows the transmission of one of the improved designs as a function of wavelength. It will be observed that the average transmission from 400 to 700 mμ is less than 10%. Since there is no appreciable absorption, this means that the average reflectivity over the visible spectrum is more than 90%. Beyond 700 mμ, the transmission rises rapidly. The average transmission between 700 mμ and 2.5 μ is about 80%. Since most of the energy from a high-intensity carbon arc is below 2.5 μ, the transmission characteristics of the heat-transmitting mirror beyond that wavelength are not shown in Fig. 3. However, the transmission has been measured out to 8 μ, and shows a sharp drop just beyond 2.5 μ. The average transmission between 2.75 and 4.25 μ is about 50%. Beyond 4.25 there is another sharp drop and the transmission from 5.25 to 8 μ is about 1%. The first drop in transmission is characteristic of absorption due to water vapor, and the second is characteristic of absorption of glass. It is unlikely that there is appreciable reflection by interference at this part of the spectrum, since the deposited films are thin in comparison to the wavelength.

The effectiveness of the heat-transmitting mirror was determined by measurements made with the arrangement shown in Fig. 4. A beam of radiant energy from a high-intensity arc lamp, a, was directed toward the heat-transmitting mirror, b, placed at an angle of 45° with the axis of the

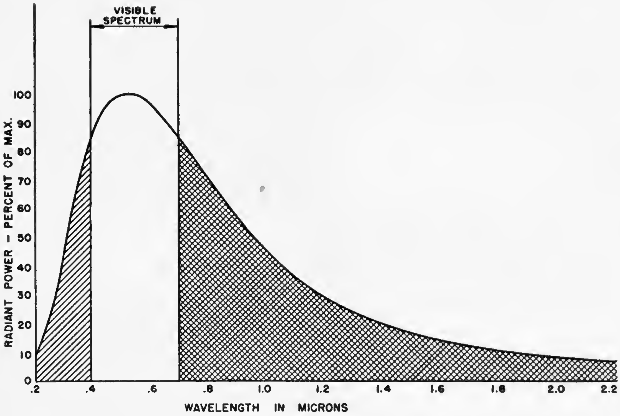


Fig. 5. Radiant power vs. wavelength for blackbody operating at 5500 K.

beam. A portion of the energy passed through the mirror and was absorbed by a black solution in the liquid cell, c. The remainder of the energy was reflected from the mirror, b, and was absorbed by a black solution in liquid cell, d. The liquid cells were identical in size and each contained the same amount of a mixture of water and India ink. An accurate thermometer was placed in each cell and the liquid was allowed to come to room temperature before turning the arc lamp on. The arc lamp was started and allowed to stabilize after which the shutter was opened. The liquid in both cells was stirred constantly and temperature readings were taken once each minute for ten minutes. The temperature readings from both cells were plotted against time, and a smooth curve was drawn through the points. Straight lines were drawn tangent to each of these curves at the starting point, where the liquid was at room temperature. The slope of each of the straight lines is proportional to the rate of absorption of energy. The ratio of the two slopes is, therefore, a measure of the ratio of the total energy reflected from the mirror to the total energy transmitted through the mirror. In the case of the high-intensity arc, the above measurement revealed that 46% of the total energy was transmitted, while 54% was reflected. Another measurement made with a 750-w incandescent lamp as a source revealed that 75% of the total energy was transmitted, while 25% was reflected. These measurements were made with the mirror at 45° for convenience. A test was made to determine the change in transmitted energy when the position of the mirror was shifted from 45° to normal-to-the-beam. There was no significant change.

The energy reflected from the mirror may be divided into two parts. The first part is due to the useful visible light between the limits of 400 and 700 mμ. The second part is the unwanted infrared energy which the mirror fails to transmit. The first value can be obtained from a curve of radiant power versus wavelength for the light source operating at a temperature of 5500 K. This is the approximate color temperature of a high-intensity carbon arc of the type used for motion picture projection. By measuring the area under the whole curve in Fig. 5 and comparing this with the area under the visible portion only, it is found that about 35% of the total energy from a high-intensity arc is radiated within the visible spectrum. Using this value, together with

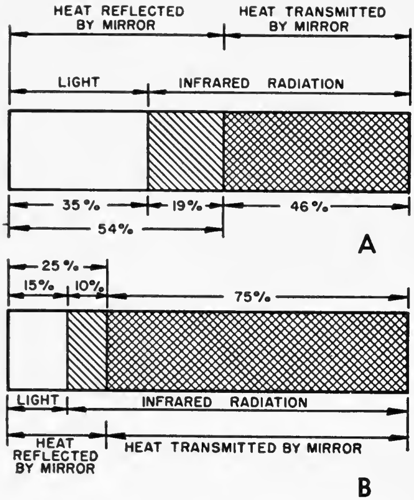


Fig. 6. Distribution of energy by reflection and transmission using heat-transmitting mirror: A, high-intensity carbon-arc source; B, incandescent-lamp source.

the previously obtained values of total reflected and transmitted energy, we can easily determine the overall performance of the heat-transmitting mirror. This is shown by means of a chart (Fig. 6). From this it may be seen that the mirror transmits more than two-thirds of the unwanted heat due to infrared radiation. It transmits nearly half of the total radiation with a loss of less than 10% of the visible light.

When used with an incandescent source, the performance of the heat-transmitting mirror is even more impressive. In this case, 75% of the total energy of the lamp is transmitted through the mirror with a loss of less than 10% of the visible light. A gas-filled incandescent lamp operating at a color temperature of 3000 K radiates about 15% of its energy in the visible spectrum between 400 and 700 mμ. Nearly 85% of its energy is radiated in the infrared region between 700 mμ and infinity. The second chart in Fig. 6 shows how the heat-transmitting mirror performs when the light source is an incandescent lamp. About 88% of the unwanted heat energy due to infrared radiation is removed by the mirror. Seventy-five percent of the total heat energy is removed, with a loss of less than 10% of the visible light.

The heat-transmitting mirror might be used in a number of ways to reduce the temperature of the film as it passes through the gate of a motion picture projector. Figure 7 shows an arrangement in which multilayer films replace the usual silver reflecting layer on the convex surface of the reflector in a motion picture projector. The glass reflector shell, c, has its convex surface, a, coated with the evaporated films which transmit a large part of the heat and reflect most of the light. A corrugated metal shell, b, encloses the back of the reflector and is spaced away from the evaporated films. This metal shell serves the double purpose of protecting the reflecting surface from contamination or mechanical damage, and absorbing the radiation so that the energy may be dissipated by convection currents.

One possible disadvantage of the scheme shown in Fig. 7 is that elaborate and expensive equipment might be required to evaporate thin films with the required uniformity on the convex surface of the reflector. This disadvantage would be overcome in the arrangement shown in Fig. 8. Here

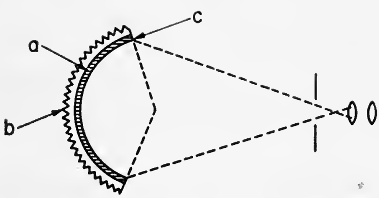


Fig. 7. Sketch of projection optics using a heat-transmitting film on back surface of reflector.

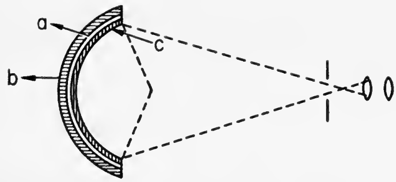


Fig. 8. Projection optics using heat-transmitting film on front surface of reflector, protected by another glass.

the multilayer film, a, is on the concave surface of the reflector where it would be relatively easy to obtain the required uniformity. In order to protect the surface from contamination and mechanical damage, a thin-glass shell is placed in front of the reflector and in contact with it all along the rim. This shell might be removed for cleaning, and it could be replaced when its concave front surface gets badly pitted by hot particles from the carbon arc.

Still another arrangement of the heat-transmitting mirror is shown in Fig. 9. The evaporated films, a, are placed on the back surface of a flat plate of glass, c. A thin, corrugated-metal housing encloses the back of the reflector and keeps it clean and free from mechanical damage. The heat is dissipated by convection currents of air flowing past the thin metal housing. This arrangement, with a single heat-transmitting mirror and a normal silver-backed concave mirror, requires a right-angle bend in the illuminating system. If this is a disadvantage, it could be overcome by the use of two heat-transmitting mirrors like those shown in Fig. 9, arranged to make an offset system with two right-angle bends. This would result in a two-stage heat filter which would be even more effective than shown by the charts in Fig. 6. If desired, a two-stage heat filter could also be obtained by using a combination of the systems shown in Fig. 7 or Fig. 8 with the system shown in Fig. 9.

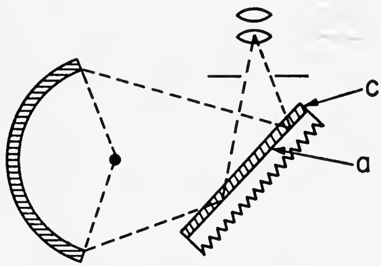


Fig. 9. Flat heat-transmitting mirror used in beams from silvered reflector.

References

1. J. Strong, "On a method of decreasing the reflection from nonmetallic substances," *J. Opt. Soc. Am.*, *26:* 73–74, Jan. 1936.
2. C. H. Cartwright and A. F. Turner, "Multilayer films of high reflecting power" (Abstract), *Phys. Rev.*, *55:* 1128, June 1939.
3. G. L. Dimmick, "A new dichroic reflector and its application to photocell monitoring systems," *Jour. SMPE*, *38:* 36–44, Jan. 1942.
4. G. J. Koch, "Interference mirrors for arc projectors," *Jour. SMPTE*, *55:* 439–442, Oct. 1950.

Discussion

Frank Carlson: What is the maximum temperature the mirrors will stand?

P. J. Herbst: No tests have been made to determine the maximum temperature the mirrors will stand. No damage has resulted from tests using the mirrors in the beam from a high-intensity arc.

D. B. Joy: Has it been found that these films will stand up satisfactorily in ordinary

projection lamps used in motion picture projection?

Mr. Herbst: The mirror has been subjected to the beam from a high-intensity carbon arc, focused to about a 3-in. diameter spot, for several hours without damage. However, actual life tests have not been made on the mirrors.

Mr. Joy: The Motion Picture Industry should be grateful to you people for having done some work along these lines. We are faced with a very practical and immediate problem of trying to keep the heat down on the film, while we are trying to force a great quantity of light through the film in out-door theaters. Therefore, anything along this line, coming at this time, will be of great help in giving us better movies, and that's the thing we want.

Mr. Strickland: If you don't have the shield in front of the mirror, and you get pretty well pitted, does that have the tendency to lower your light?

Mr. Herbst: You mean the dichroic on the front of the mirror next to the carbon arc?

Mr. Joy: That's right.

Mr. Herbst: This would not be recommended. The dichroic surface should be protected.

Recent Improvements in Silencing Engine-Driven Generators

By L. D. GRIGNON

A gasoline engine-driven, 120-v, d-c generator of 150-kw output for set lighting on location has been improved. The enclosing wall structures, materials and carburetor air-intake were changed. When mounted on a trailer the exhaust and radiator and noise are considerably reduced by methods described. The improvements permit sound recording with the generator as close as 250 ft under reasonably favorable circumstances and not exceeding 750 ft for critical conditions. Considerable saving in production costs results.

The silencing of noisy equipment used in the production of motion pictures has been a continuous problem since sound recording became a part of the industry. One of the most offending equipments has been the engine-driven generator used for set lighting on location, although the accumulated contributions of many workers have produced considerable improvement over the initial situation.

The problem which led to the improvements reported herewith was posed as follows: Given a gasoline-engine-driven, direct-current generator set of 150-kw capacity of the basic design described by Hankins and Mole[1] and of similar size, what changes or modifications can be made to obtain a plant with less noise?

The difficulty in work of this kind is to find the best compromise between size, weight, cost, operating features and quietness. As is well known, quietness is not compatible with the first three items.

The design previously produced by the Mole-Richardson Company was carefully studied with these conclusions: that some change in structure shape would permit mounting the engine and generator on a noise-insulated subbase; that it was reasonable to expect improvement in wall design; and that better sound absorptive materials might be used. The design of the subbase was undertaken by the Mole-Richardson Company with the application of conventional vibration insulation methods. Further, in consultation with the same company and the engine manufacturer, it was concluded that the engine could be completely enclosed and adequately cooled by water only.

The next step, in order, was to consider the enclosing structure. Figure 1 illustrates the basic layout.

Presented on October 19, 1951, at the Society's Convention at Hollywood, California, by L. D. Grignon, Twentieth Century-Fox Film Corp., Beverly Hills, Calif.

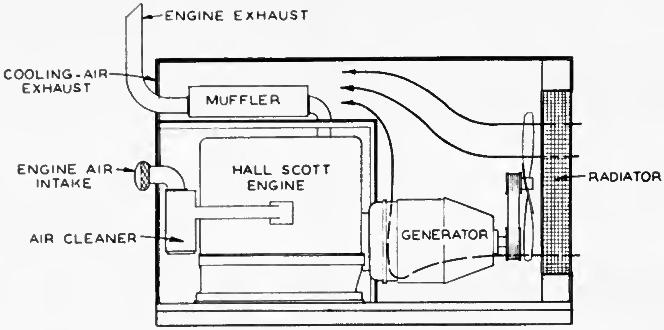


Fig. 1. Basic plan of enclosure.

Three principal factors determine the efficacy of sound-insulating structures. These are absorption, transmission through the various media and element resonance. When the maximum amount of absorption at the sound source can be provided, the two latter problems are somewhat simplified. Of first importance, therefore, is the selection of absorptive materials for the inside surfaces of the enclosing structure. Again, a balance of thickness, weight and absorption must be determined and, to complicate matters, the material must be fireproof in this particular application.

A material having a good balance of these factors is known commercially as Spraycoat. This is a shredded asbestos material with a suitable high-temperature flameproof binder. It is applied by spraying and tamping, preferably on wire mesh or plaster wire. If some air space is provided behind a $\frac{3}{4}$-in. layer of this material, very good low-frequency absorption is attainable and since it is of a semiporous soft nature, the high-frequency absorptive qualities are excellent. Whenever the material is applied in this manner, the support must be reasonably taut in order that the tamping operation will be satisfactory. The material is not mechanically strong and in areas where this is of importance it is desirable to protect the surface with wire mesh. An additional mechanical help is to spray the surface with a thin application of water-base casein paint.

Wherever possible, the interior surfaces of the enclosing structure have been covered with Spraycoat. In a few specific instances, for mechanical reasons, an air-duct felted material with an asbestos-cloth facing known as Dux-Sulation has been used.

Panel or structure resonance is of great importance for, if resonance exists, the structure will apparently have small transmission loss in contradiction to the predicted loss value based on the materials used. One method used in the past for minimizing resonance consisted in designing the panels in random sizes. This is of value in that such resonances as do exist are distributed in the frequency spectrum and the added bracing provides some damping. A better solution would be some method which eliminated resonance, regardless of the panel spectrum distribution. This implies that damping is the important factor and accordingly design effort was directed to this specific aspect.

The most generally used panel-damping method is the application of non-hardening asphaltic or rubberlike materials. These do provide some damping and lower the panel-resonance frequency by virtue of the added weight, but in many ways this method is not very satisfactory. The most favorable

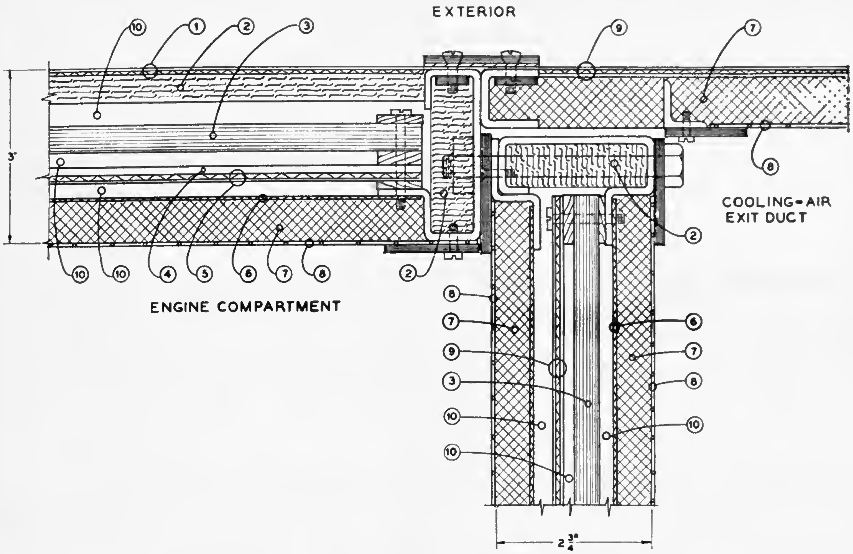


Fig. 2. Types of wall sections showing juncture of engine compartment and cooling-air exit duct.

1. Stainless-steel, 20-gauge Type 302 plus 2 layers Brownskin building paper cemented with Minn. Mining EC-1025.
2. Dux-Sulation ½ in. thick cemented with Dux-Sul Glue.
3. Celotex ½ in.
4. Minn. Mining Undercoater EC-831, ⅛ in. thick.
5. Aluminum 0.040 2S plus 1 layer Brownskin Grizzly Bear 30/40 building paper cemented with Minn. Mining EC-1025.
6. Metal Lath 3.4 lb.
7. Spraycoat ¾ in.
8. Hardware cloth 17-gauge, ⅝ in. × ⅝ in. mesh.
9. Stainless-steel, 20-gauge Type 302 plus one layer Brownskin Grizzly Bear 30/40 building paper cemented with Minn. Mining EC-1025 to steel and 0.040 aluminum 2S.
10. Air space.

aspect of the so-called "undercoaters" is low cost. Certain heavy, creped building papers have been found to provide excellent damping when cemented between two panels in laminate form. In such form, panel vibration establishes sheer forces within the damping paper which dissipates the energy. A single metal sheet with cemented paper is reasonably well damped and may be used, when indicated, with good results.

With good damping and high absorption attained, attention may be directed to the reduction of sound transmission. The classical considerations of transmission loss now more nearly apply in the practical case by virtue of the significant reduction in resonance. It is known that two separate structures have greater transmission loss than the same total amount of material in one structure, but this scheme complicates the construction, makes for increased size, increased weight, difficulties of access and maintenance. Wall structures with air spaces also provide more transmission loss than the same amount of material in a solid wall, but are

usually more conservative of space than the separate wall design, although lower attenuation can be expected. An additional factor to be considered is that motion picture dialogue sound recording is usually attenuated at the low-frequency end relative to midband and a high-pass filter is used. It is, therefore, illogical to provide high attentuation below 100 cycles.

Wall Sections

Considering all items discussed above, wall sections as shown in Fig. 2 were devised. The illustration shows the joint between three different sections as follows: the left-hand section between the engine compartment and the outside; the right-hand section between the cooling-air exit duct and the outside; and the vertical section between the engine compartment and the cooling-air exit duct. The materials are shown in the illustration, but the outer skin requires more explanation.

For durability and appearance the outside material is stainless steel damped with two layers of creped building paper. Since the paper is creped in only one direction and light in weight, two layers at right angles give good damping. The paper is cemented together and to the metal with a Minnesota Mining nonhardening adhesive. The single metal-paper laminate is used in this location because it is desirable to face the inside surface with an absorptive material to minimize reflections in the adjacent air space and to lower the unit weight of the section.

Both the air duct and the engine compartment must be faced with highly absorptive material. Because of a dimension limitation, the wall between these regions is modified slightly to include a metal-paper-metal laminate panel. The use of the metal-paper-metal laminate maintains the transmission loss at a suitable value which would otherwise have been decreased, due to the removal of the damped aluminum panel used in the other principal wall section. Obviously, the air-duct wall requirements are considerably less severe, so here the principal attenuation is provided by a metal-paper-metal laminate with Spraycoat applied directly on the inside.

The actual attenuation of the main wall sections is not precisely known due to a lack of facilities for this type of measurement. By calculation and considered judgment, it seems reasonable to assign an attenuation value of 43 to 50 db at midband and somewhat less at 100 cycles. The attentuation is, however, ample, since by methods to be mentioned later whereby the residual noise is considerably reduced, noise through the wall sections is still far below all other sources.

As a matter of refinement and precaution, all structural members are filled with Dux-Sulation. It will also be noted in the illustration that the wall section can be disassembled from the outside if it is necessary for any reason.

Doors for access to the equipment are a necessity and in the past the most popular idea has been to use a stepped jamb with multiple rubber or felt gaskets and a latch which compresses the frame and jamb upon the gaskets. This construction is commonly known as the "icebox door." This method is satisfactory as a sound-stopping scheme, but is cumbersome, requires heavy hardware and loses effectiveness as the gaskets are damaged or deteriorate with age. If a door is made with sufficient accuracy so that the residual crack is of small dimensions, only high frequencies will be transmitted by this path. Further, high frequencies are readily absorbed by many different materials, so that any material which can be introduced within the residual crack will considerably reduce the high-frequency transmission. This is the basic design idea used in the subject project, and the actual construction is shown in Fig. 3. The design requires no especially heavy

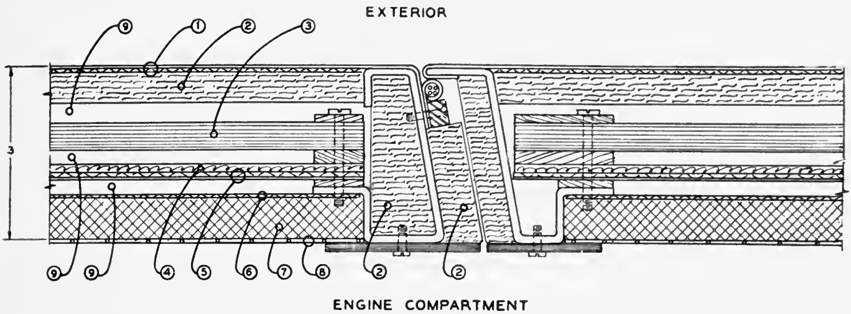


Fig. 3. Section of engine compartment wall including access door construction.

1. Stainless-steel, 20-gauge type 302 plus 2 layers Brownskin building paper cemented with Minn. Mining EC-1025.
2. Dux-Sulation $\frac{1}{2}$ in. thick cemented with Dux-Sul glue.
3. Celotex $\frac{1}{2}$ in.
4. Minn. Mining Undercoater EC-831, $\frac{1}{8}$ in. thick.
5. Aluminum 0.040 2S plus 1 layer Brownskin Grizzly Bear 30/40 building paper cemented with Minn. Mining EC-1025.
6. Metal lath 3.4 lb.
7. Spraycoat $\frac{3}{4}$ in.
8. Hardware cloth 17-gauge, $\frac{5}{8}$ in. $\times$ $\frac{5}{8}$ in. mesh.
9. Air space.

hardware, no pressure is required to close the door and there is no audible noise transmission through the door joint. The gasket shown serves principally as weather stripping and makes the final closure of the door crack. If the crack can be held to $\frac{1}{16}$ in. or less by good construction, about a 40-db noise attentuation can be expected. An empirical rule to estimate the loss through a joint as shown is to allow 1 db for each unit of sound-path length, the unit being equal to the crack width.

As is apparent from Fig. 1, the generator compartment is open to the air through the water-cooling radiator and, therefore, it would be poor design to provide the same excellent wall structure for this volume as was used for the engine compartment. Accordingly, the wall structure used in these areas was the identical simple section of the exit air duct.

Air Exit Duct and Mufflers

The cooling-air exit duct is of interest in that no baffles or turns are used. The duct is straight and open from the generator compartment to open air, a distance of 63 in. Two vertical separators are placed in the duct to provide more surface for absorptive Spraycoat.

The duct has cross-section dimensions of 15 in. $\times$ 50 in. and absorbs the generator and fan noises so well that this potential source of noise needs no other attention.

Several good engine-exhaust mufflers are available, hence the only precaution to be observed on this item is that the muffler itself does not become a noise source. This difficulty can be minimized by wrapping the muffler with sheet asbestos held tightly to the muffler surface with an external wrap of sheet metal.

Carburetor Intake

A situation contrary to that of the engine exhaust concerns the engine carburetor air-intake. If outside cool air is to be used for the engine, then the noise from this source needs considerable attention when, as in this case, the other

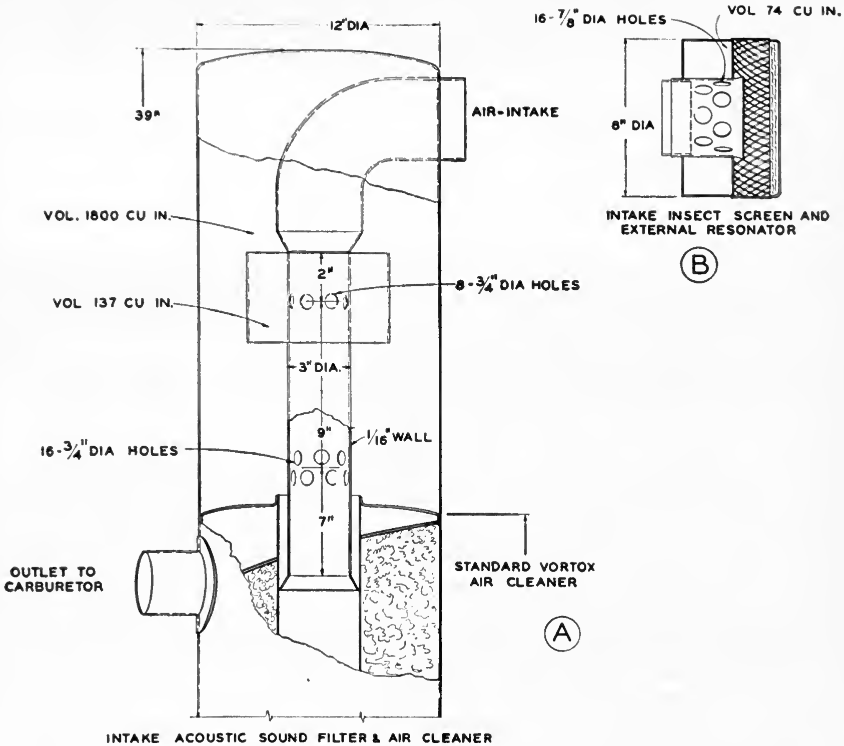


Fig. 4. (A) Basic design of carburetor air-intake acoustic filter as combined with standard Vortox air cleaner. (B) Design of external resonator and insect screen for carburetor air-intake.

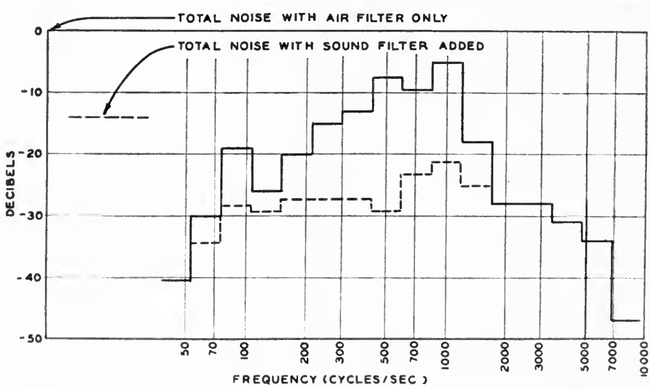


Fig. 5. Noise frequency distribution, carburetor air-intake. One-half octave band frequency analysis of source noise showing attenuation due to acoustic filter and external resonator.

major noise sources have been minimized. The usual sound attenuation is that due only to the dirt filter; therefore, an acoustical low-pass filter was designed having the configuration of Fig. 4A. It will be noted that two dissimilar volumes are used: the through pipe is smaller in cross section than the carburetor intake and the acoustic filter has been combined with the Vortox air cleaner to make one package.

The classical theory for design of acoustic low-pass filters assumes that such devices are inserted in the middle of a long pipe or conduit. In the practical case under discussion this is not true, since at one end there is a relatively short pipe, while at the other end there is the volume of the air cleaner and the acoustic resistance of the oil-saturated meshes. These discrepancies were neglected and the large single-section filter computed by the simplified formulas of Stewart,[2] rather than those more complete and complex equations of Mason.[3] One difficulty with acoustic filters concerns the terminating impedances, since an impedance match occurs only at discrete frequencies. In general, if the filter matches the con-

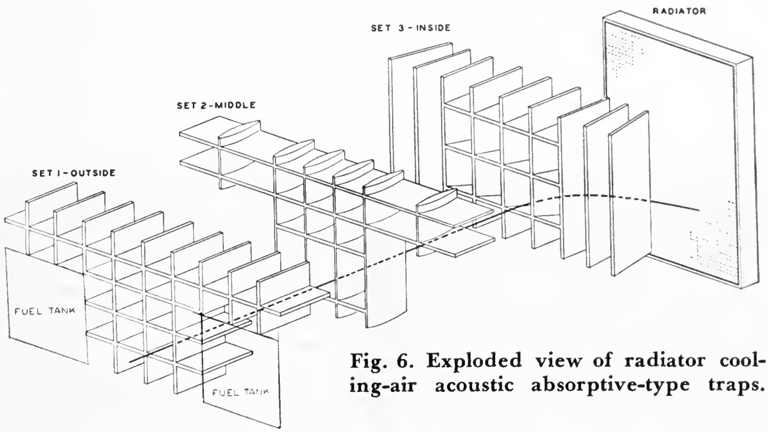


Fig. 6. Exploded view of radiator cooling-air acoustic absorptive-type traps.

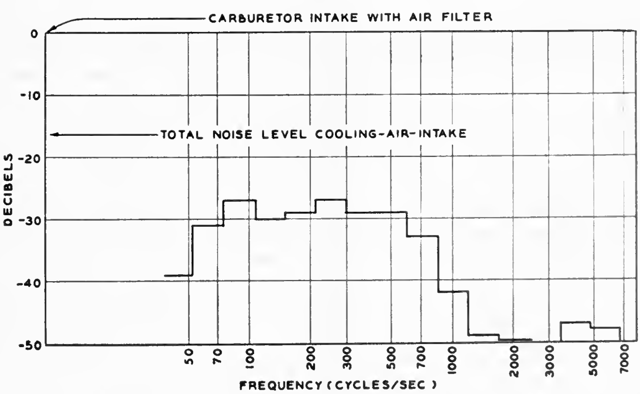


Fig. 7. Noise frequency distribution — radiator end related to carburetor intake noise with air filter only, full load. One-half octave band analysis of source noise from radiator end after installation of absorptive trap.

necting impedances at some frequency low in the passband, superior performance may be achieved. The smaller-sized pipe in the filter assists in reducing the filter impedance to improve the match, but is not of such small size as to restrict air flow.

Another difficulty with acoustic filters results from passbands above the cutoff frequency. When additional series-connected-filter sections with different cutoff frequencies, other than multiples of the preceding sections, are used, the spurious passbands are minimized. This is the reason for the section containing the second smaller volume. The cutoff frequencies of the two sections are 80 and 350 cycle/sec, respectively. Using the device as illustrated, considerable improvement obtains, although there is still a peak of transmission around 900 cycle/sec. Discrete frequency bands above 300 cycles may easily be eliminated by small Helmholtz resonators coupled to the intake pipe at the open-air end, and in this instance may be combined with the insect screen. Such a resonator is shown in Fig. 4B and the total effect of the above-described filter and resonator is shown in Fig. 5. The measurement of total noise level shows a 14-db improvement. The frequency distribution was measured in one-half octave bands from a recording made on a standard production dialogue recording channel.

In this particular application the two volumes of the filter may actually be operating as resonators coupled to the pipe, rather than as a true low-pass filter. This point needs investigation before a clear-cut understanding of the situation may be available, but in any event the configurations described have adequate performance for the requirements. The loss in horsepower due to the acoustic filter is 0.33% at sea level, full power, wide open throttle.

The principal remaining noise emanates from the radiator end and results from the large slow-speed fan and the generator. There is very little that can be done about this source without making the plant considerably larger except to absorb as much of the noise as possible. This is done, as described, by using Spraycoat and as much Dux-Sulation around the generator end-bell as possible.

All of the access methods and operating features described by Hankins and Mole have been retained in this overall design.

As described above, the plant is a complete unit of relatively low noise level which can be shipped by any common means of transportation.

Further Quieting Methods

For the great majority of motion picture locations a generating plant as described may be placed on a permanent truck or trailer, provided that, when required, it may be easily removed. When considerable long-distance hauling is to be done, a low-bed trailer is of advantage. Consequently, the described unit has been mounted on a low-bed trailer with permanently installed fuel tanks. This procedure provides space which may be used for additional silencing.

The plant was so placed on the trailer that the added space came at the radiator end. The volume from the radiator to the end of the trailer was enclosed with sheet metal, lined on the inside with 1-in. preformed glass-wool sheet. This enclosure included the fuel tanks. Three sets of straight-through vertical and horizontal partitions (commonly called egg-crates) are placed in the air stream, as shown in the exploded view of Fig. 6. Each of these is approximately 16 in. long with all surfaces covered with Dux-Sulation. The center set has the vertical partitions constructed so that a cross-sectional view of any two adjacent partitions form an air path having the approximate shape of a Venturi tube. The three sets of partitions are separated by free-air spaces of 14 in.

Fig. 8. Photograph of basic plant installed on trailer.

to 16 in. in length. Also, the number of vertical and horizontal members are different in each set so that if stacked one upon another the combination would appear as a set of irregular-sized openings, each being smaller than any single opening in any set of partitions. The total area of the sound-absorptive material within the traps is approximately 400 sq ft and though the air travel is essentially straight through, a reduction in noise power of 14 db is achieved. The noise spectrum is shown in Fig. 7. It is believed that considerable benefit obtains from the free-air volume between the partition sets. There has been no noticeable reduction in cooling efficiency by the application of this particular arrangement in the air path. Indeed, there is some evidence that the plant runs cooler under given conditions with this sound trap.

With the noise reductions obtained by the methods so far described, the exhaust noise became noticeable. This source is easily reduced by additional muffler capacity and in this particular case was most easily accomplished by the addition of a second muffler essentially the same as the permanently installed unit. The second muffler was also lagged with asbestos and sheet metal.

Final Plant

With all the methods and devices described, the plant appears as in Fig. 8. When necessity demands, the minimum plant is removed from the trailer and is used with some penalty in noise output requiring longer cable runs or temporary housing structures. When used complete, as shown, the plant may be used 250 ft to 750 ft from the recording set, the distance being determined by the nature of the scene and the conditions of the location. Distances of 300 ft to 400 ft are the usual placement for the average scene. The savings in cost and time on location resulting from close generator placement are obvious.

Acknowledgments

As is so often the case, this project was successfully completed with the assistance of many people. The plant itself was contracted to the Mole-Richardson Company where M. A. Hankins was of considerable help in designing the structure for the plant enclosure; Standard Auto Body Company was of great value in suggesting structure construction methods leading to good mechanical design at reasonable cost and for excellent assembly of the enclosure; the Vortox Company was very cooperative in making sample acoustic filters combined with their standard dust filter until a suitable design was found. Lastly, the project was guided by Walter Strohm and Thomas T. Moulton of Twentieth Century-Fox Film Corporation, Electrical Engineering and Sound Engineering Departments.

References

1. M. A. Hankins and P. Mole, "Designing engine-generator equipment for motion picture locations," *Jour. SMPTE, 55:* 197–212, Aug. 1950.
2. George W. Stewart and Robert Lindsay, *Acoustics,* D. Van Nostrand, New York, 1930.
3. Warren P. Mason, *Electro-Mechanical Transducers and Wave Filters,* D. Van Nostrand, New York, 1948.

Discussion

Anon: Thank you very much, Mr. Grignon. On the egg crate, was there any acoustic material?

L. D. Grignon: Yes, all the partitions are covered with a felted flameproof material ½ in. thick.

David Joy: I noticed that you showed a general lowering of the sound level and also you had the curves showing the lowering of the sound level for the individual frequencies. Why are you so interested in the individual frequencies, if you have the general sound level low; why do you have to worry about the individual frequencies?

Mr. Grignon: Equipment noise seldom has the sound energy uniformly distributed throughout the audible spectrum. By making an analysis of the noise, cycle by cycle, or in discrete bands as was done in this instance, a determination can be made of those portions of the frequency spectrum contributing the greatest energy relative to the total sound energy. In some cases the noise source can then be identified and corrections at the source applied. When it is impossible to correct the source, the greatest benefit can be obtained by assuring that the external corrective means is most effective in the frequency bands containing the largest percentage of the energy.

Harry R. Lubcke: Grig, could you estimate what proportion of the weight was added to the original weight of the engine-generator set by the sound-insulation job?

Mr. Grignon: I might make a guess at it, but I think that we can probably get a more accurate figure by asking Mr. Hankins of the Mole-Richardson Company whom I see in the audience.

M. A. Hankins: The total weight of this particular engine-generator set is 10,660 lb, including the sound-insulating housing which weighs 2440 lb. The weight of the plant less housing is, therefore, 8220 lb. Assuming that the baffling added in front of the radiator, etc., by Twentieth Century-Fox weighs approximately 800 lb, the gross weight of all the sound-insulating components is 3240 lb, which is about 35% to 40% of the basic weight of 8220 lb.

Cinecolor Multilayer Color Developing Machine

By JAMES W. KAYLOR and A. V. PESEK

The development of the various new and improved multilayer color films emphasized the need for a standard-type motion picture film developing machine that would be capable of handling any of the new types of multilayer color films. A machine of deep-tank, positive top-drive type embodying bottom elevators, turbulation or spray facilities in all tanks and practical flexibility, enabling it to be set up in any practical combination of solutions and washes to develop the various types of multilayer color films available, has been developed and put into operation as a production machine by the Cinecolor Corporation. A special arrangement of the geared drivehead allows any of the racks to be removed without affecting the drive, and the drive has been designed to provide for the attachment of desired auxiliary equipment.

When the Cinecolor Corporation began the major conversion of its facilities to the production of three-color film, it was necessary to have a developing machine for the multilayer color film which was to be used as the taking medium. At that time it was decided to try to design a standard-type machine which would be flexible enough to develop any of the color-coupling multilayer films available. Such a machine could be set up as an experimental machine to evaluate the possibilities of the various films or as a production machine to process any specific type of film and still retain flexibility to permit change-over from one system to another with a minimum of rework.

The developing machine was designed to operate at an average speed of 35 ft/min with a minimum and maximum speed of 10 to 60 ft/min. A study of the developing techniques of the several multilayer color films indicated that 32 racks, each having a capacity of approximately 100 ft or a time element of about 3 min at 35 ft/min, would be sufficient to provide for the different combinations of solution and wash times indicated for the various films. Figure 1 shows diagrammatically the general layout for several different films.

In order to provide for different combinations of solutions and washes 32 tanks are used, one for each film rack. All tanks are identical, with side

Presented on October 17, 1951, at the Society's Convention at Hollywood, Calif., by James W. Kaylor and A. V. Pesek, Cinecolor Corp., 2800 West Olive Ave., Burbank, Calif.

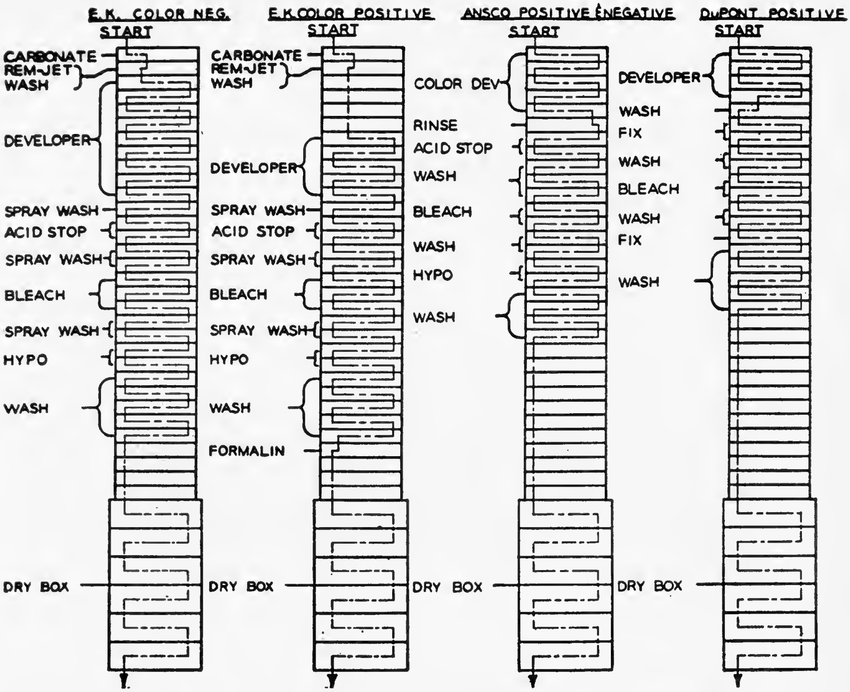


Fig. 1. Diagram of general layout for several color films.

inlets and outlets for supply, overflow and drain and with six additional fittings in each side to allow for the insertion of turbulation or spray headers, as shown in Fig. 2. On the drain side of each tank are provided two overflow fittings as well as a drain fitting at the bottom, as can be seen in Fig. 3. The additional overflow fitting is set lower than the regular overflow to provide for a submerged level control, when desired, to eliminate excessive oxidation of solutions if air is entrapped by overflow into the usual open-type return line.

The tank drive frame can be seen lowered into operating position in Fig. 4 and raised for cleaning and checking in Fig. 5. This is a tubular frame, one side of which acts as an integral gear and shaft housing for the main gear shaft that drives all of the film racks. Power is provided to the head through a right-angle gearbox from a telescoping power shaft which allows the drive frame to be run in either the raised or lowered position. The individual film roller racks are attached to the top of the tubular drive frame by two identical castings. One carries a helical gear which meshes with a similar gear within the tubular shaft housing and drives the top roller shaft through a tongue-and-key joint; the other carries a ball-bearing pin which supports the outboard or idler end of the top roller shaft. An adjustable tierod connects the two castings to maintain alignment and stiffen the whole driving head. Each casting supports two hanger rods, which in turn support the back-up roller (midway between top and bottom rollers) and the bottom roller elevator, as seen in Fig. 5. The extreme lower ends of the hanger rods are clamped

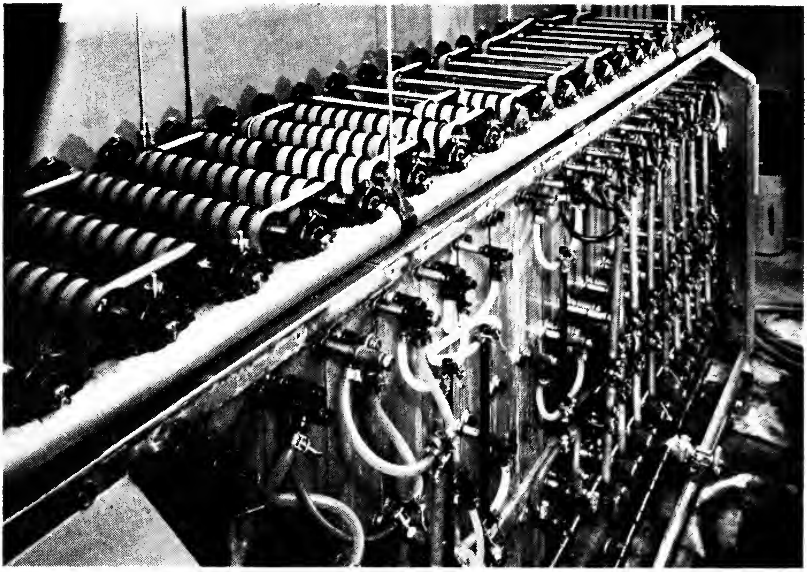


Fig. 2. Inlet side of tanks, with chemical supply lines and turbulation headers.

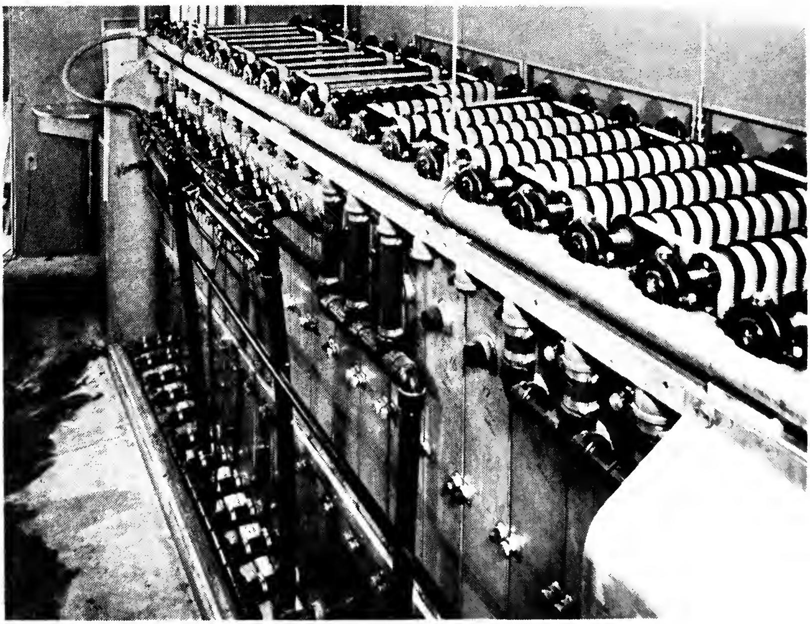


Fig. 3. Drain side of tanks.

with phenolic hangers and tied together with another tierod to insure proper spacing. The phenolic hangers also act as guides when the rack assembly is being lowered or raised in the tank.

Positive drive is applied to the film by means of a single drive sprocket setscrewed to each top roller shaft. Eleven film rollers are mounted in connection with the sprocket on a full standard rack, and are free-running on the shaft with molded, phenolic bearing inserts which also maintain correct spacing of the rollers. Additional drive is obtained, if necessary to relieve tension, by slightly spring-loading the rollers together.

The bottom roller elevator consists simply of two phenolic hangers, each clamped to two short lengths of stainless-steel tubing that ride up and down on the two hanger rods on each side. The lower shaft is slipped into holes in the hangers and centered by setscrew collars at each end. The whole assembly is tied together by a separator assembly which also keeps the film strands properly aligned with the bottom rollers. These are free-running on their shaft and spaced by molded, phenolic bearing inserts, the entire weight of the bottom elevator assembly being supported by the film strands.

The complete drivehead can be raised or lowered by six stainless-steel cables connected to an electrical hoist. The cables are conveniently spaced three to a side, as shown in Fig. 4, and are adjustable with turnbuckles to equalize tension and insure a straight and even lift. The hoist is provided with an electrically operated brake which minimizes coasting and holds the head in any position desired. Two limit switches are mounted on the ceiling, one at each end of the head to prevent it from being raised too far.

Film is fed into the machine from a clutch spindle mounted on a feed table. The film passes first over a feed elevator of approximately 100-ft capacity which allows about 3 min for splicing on new rolls. After passing through the tank section, the film moves through an air blowoff or squeegee and into the dry box. The blowoff unit is hinged so that it can be tipped down out of the way when the drivehead is to be raised to the ceiling. Air is supplied to the blowoff from a Nash waterseal compressor at about 2 to 3 psi, through a manifold which is also extended the length of the tank section with outlets at the center and feed end for connection to various auxiliary equipment.

The dry box, shown in Fig. 6, is of sheet-aluminum construction with three sliding glass doors on each side. The drive is a positive top drive, similar in construction to the tank drive, and consists of a tubular frame with the drive gear shaft and castings previously described, but mounted inverted, with the castings on the bottom, on four corner supports. The drive has six banks of rollers or film racks, the lower rollers being ball-bearing and mounted on elevators. Centered between the top and bottom rollers on each rack there is a back-wiping roller to remove any drops or streaks from the base side of the film as well as to keep the film strands separated. The dry box holds approximately 900 ft of film giving about 27 min drying time at 35 ft/min. Air is supplied to the dry box under controlled temperature and humidity conditions from a heating and blower unit. Temperature and humidity are provided by a steam supply and are regulated by Minneapolis-Honeywell controllers.

The dried film is taken up as it leaves the dry box on either of two power-driven, friction-clutch take-ups (two are provided for rapid change-over) which are shown in Fig. 6. Power for the take-ups is supplied from a separate gear-head motor of sufficient output speed to drive the take-ups at the maximum speed of 60 ft/min.

The machine speed controls and speed indicator are mounted on a panel be-

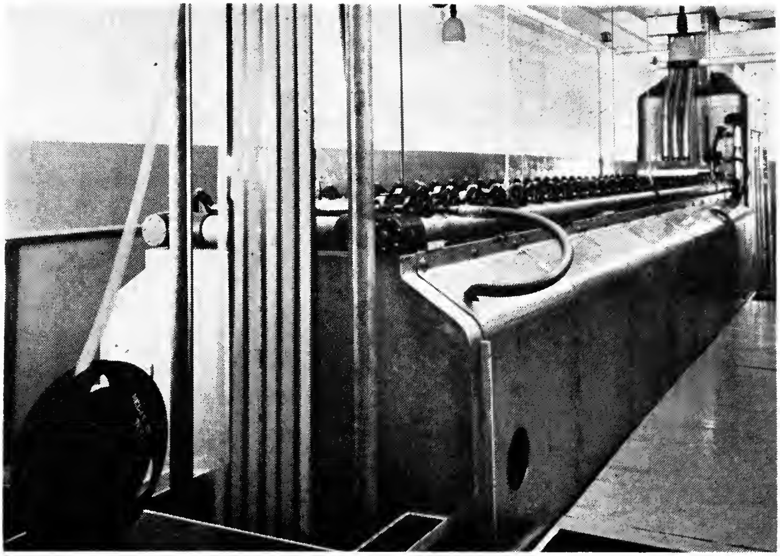


Fig. 4. Tank section of machine with drivehead in operating position.

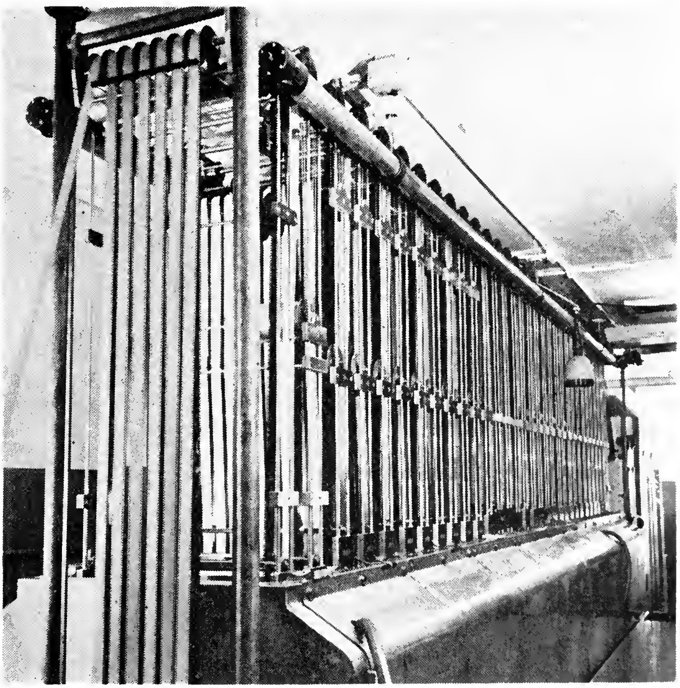


Fig. 5. Drivehead raised for maintenance or thread-up.

tween the tank section and the dry box cabinet. Speed of the machine is governed by a speedranger, located below the floor, which is adjusted with a chain drive from the speed-control knob on the panel. Also on the panel is one of three stop-start stations, the other two being mounted on the feed table and take-up table, respectively.

Water is supplied to the various wash tanks through a common header. Deep wash tanks are fed through the bottom inlet and overflowed into the open drain at the top of the tank. Spray wash tanks are fed directly through the six spray headers inserted through the sides of the tank, and drained through the bottom drain.

The chemical solutions are supplied to the proper tanks from storage tanks located in the basement through Saran piping and headers. Solution return is effected by gravity flow from overflows to the storage tanks. Individual pumps are employed for each solution, and flow is metered through Schutte-Koerting Rotameters. Submerged drains are provided on the developer tanks and the level is controlled by means of wet-type liquid level switches actuating solenoid valves on the lower end of the drain lines.

Turbulation of the chemical solutions is accomplished where desired by withdrawing the solution from the machine tanks through the bottom drains and pumping it back through the spray headers. The turbulation flow is also metered through Rotameters.

Temperature control of the solutions is maintained by passing either hot or cold water through stainless-steel, heat-exchange coils installed in the solution storage tanks. However, the problem is primarily one of cooling the solutions, so Taylor Temperature Recording Controllers are used to regulate the chilled water supply to each coil, hot water being used only to warm the solutions after shutdowns during cold weather, when occasionally the solution temperature drops below the required point. A portion of the basement section can be seen in Fig. 7, showing tanks, temperature controllers, flowmeters, and solution supply and turbulation pumps.

The machine described in this paper has been operated very satisfactorily as a production machine for over twelve months. Considerable interest in it has been shown in the industry. A second unit, similar to the first, is now being readied to increase the capacity of color-coupling multilayer film processing by the Cinecolor Corporation.

Acknowledgment: We wish to acknowledge with thanks the helpful cooperation of R. W. Lorenzen, O. W. Murray, J. K. Stewart, E. W. Rutherford and the many others who contributed to the design and development of the Cinecolor Multilayer Color Developing Machine.

Discussion

John G. Stott: Did I understand that you turbulate your bleach solution? Could I ask why?

James W. Kaylor: It was recommended, more or less, in the instructions for the technique of developing the EK color film that we use at the present time.

Mr. Stott: Well, the usual use to which turbulation is put, is in a stage of chemical processing, where the process doesn't actually go to completion, but where you want to make all the film go to the same point at the same time. In other words, you want all the film to be processed uniformly, but the fixing operations and the bleaching operation are usually considered as going to completion, so that turbulation is, as I see, of absolutely no use.

Mr. Kaylor: Well, I can say that we have tried it both ways, with turbulation and without, and it was decided to use the turbulation method. I believe that that question probably could be answered a little more fully in the paper that Mr. E. W. Hart is going to read tomorrow night, I believe, describing our three-color

Fig. 6. Dry box and take-ups.

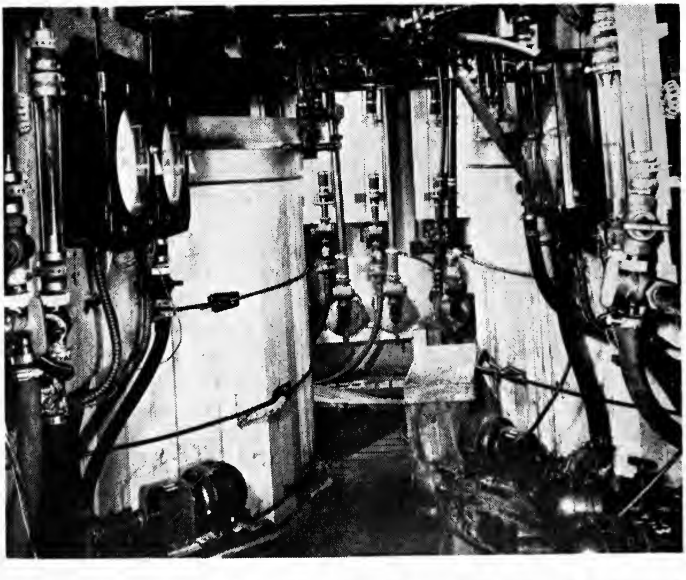


Fig. 7. Section of basement showing storage tanks, temperature controls, chemical pumps and flowmeters.

process, also going through the various steps of the developing of our EK negative.

Mr. Stott: What is the total amount of film in the developer section?

Mr. Kaylor: At the present time, it is pretty close to 3000 ft. I say at the present time because the machine can be set up to take a total of about 3200 ft of film, but in some of the tanks we do short strand because we need much less than three minutes' developing time, three minutes', let's say, chemical time in those particular tanks; in fact, in one or two of the tanks we have only a couple of feet of film.

Mr. Stott: Are your bottom rollers floating rollers?

Mr. Kaylor: Yes, they're floating rollers. The bottom rollers are all mounted on elevators, with one exception where we have them fixed to maintain a certain amount of tension. I might say, perhaps, that in this auxiliary equipment that was mentioned — in the EK machine, for example — it was found necessary to install what we call a rem-jet remover roller, to take off the jet-black backing of the film. We had to install a velvet-covered roller midway down into a tank and use that to buff off the anti-halation backing.

Edward H. Reichard: In the pictures of the machine, I noticed that your top rollers in the developing section are out of the solution. Is that right?

Mr. Kaylor: No. Perhaps I should have explained that in our developer section we actually use submerged drives — the nine shafts there are submergible beneath the solution level.

New Magnetic-Recording Head

By MARVIN CAMRAS

A three-pole magnetic head produces a magnetic field at the recording gap which is more uniform throughout the thickness of the magnetizable layer, and decays more rapidly at the trailing edge. With this head, optimum bias is practically the same for high as for low audiofrequencies. High audiofrequencies are recorded at a 3-db to 7-db higher output level before distortion as compared with a similar head of conventional design.

Two important factors have made possible the present-day low magnetic-recorder speeds: (1) thin, uniform recording tapes with high magnetic properties; and (2) efficient magnetic heads with very short gaps.

Effect of Short Gaps

Efficiency and short gaps do not go together, unfortunately, because, as the gap is shortened, more of the useful flux tends to be lost across the pole faces. The situation for a playback head is shown in Fig. 1. A recorded signal such as A produces a certain external flux which is utilized more or less efficiently to thread a voice coil. At the pickup gap some of the flux from the record follows path B through the core and through the voice coil. But other lines of flux such as C and D prefer to take the short path across the faces of the pickup gap. Still others, such as E, complete their circuit through the air or backing material on the side opposite the gap.

The flux divides inversely according to the reluctance of each path. A gap measured in tenths of a thousandth of an inch may have less reluctance than an inch or two of high-permeability core material. Consequently, it may waste a major portion of the playback flux.

When we use such a short gap for recording as in Fig. 2, we find that practically all of the flux concentrates in the easy path across the short gap, and a much lower field acts on the record material, especially on the side away from the gap.[1] As we increase input to the head to produce an adequate recording field, we find that the head core approaches saturation, and in many cases we cannot reach optimum recording conditions regardless of how much input we feed into the voice coil.

A third problem of magnetic heads, that of maintaining good contact with the record, becomes much more important as the gap is decreased. Studies show that even with ordinary heads,

Presented on October 18, 1951, at the Society's Convention at Hollywood, Calif., by Marvin Camras, Armour Research Foundation, Illinois Institute of Technology, 35 West 33 St., Chicago 16, Ill.

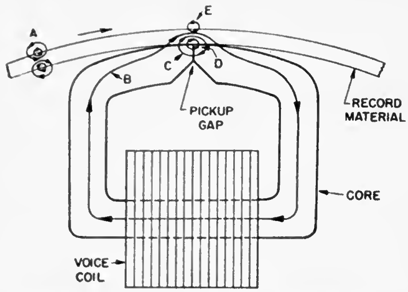


Fig. 1. Flux paths in a magnetic head on playback.

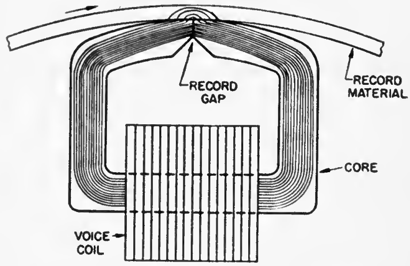
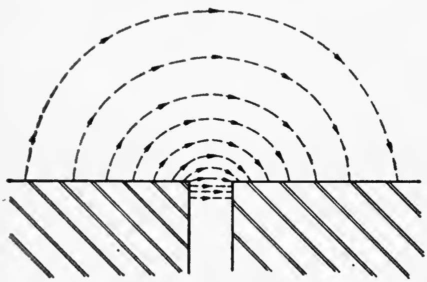
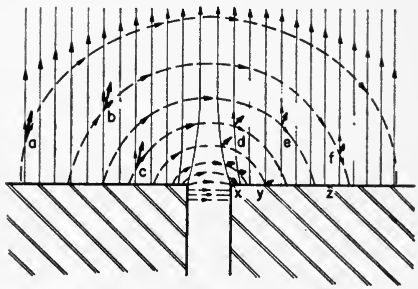


Fig. 2. Flux paths in a magnetic head during recording.



A. Magnetic field produced by gap.



B. Superposed cross field adds vectorially to the gap field.

Fig. 3. Flux paths of an X-field head.

a separation of only 0.0001 in. causes marked fall-off in high-frequency response.[2] With shorter gaps, a 0.0001-in. spacing would be fatal. Thus, a decrease in record or playback gap, by itself, does not solve the problem of obtaining better resolution.

The Cross-Field Head

With a conventional head the magnetic field at the recording gap is as shown in Fig. 3A. As an approximation, it has a semicircular direction with respect to the gap center and decreases inversely with the distance. Ordinarily we have little control of the shape of this field. Suppose we now provide a vertical field as in Fig. 3B and combine this field with the semicircular field of the gap. (The additional field is termed a *cross field* or *X-field*, and a head which provides such a field is called an *X-field head.*) Vector addition of the components, as, for example, a, b, c, d, e and f in Fig. 3B, gives some interesting results:

1. On the left-hand side of the gap, the components are additive, and the resulting field is stronger and more nearly vertical than the gap field alone.

2. On the right-hand side of the gap, the vertical components oppose each other, and can be adjusted to cancel at some point near the right-hand edge of the gap. For example, in Fig. 3B near the surface of the right-hand pole, at x, the gap field predominates; while at z the cross field is stronger. Somewhere in between, near y, cancellation occurs, leaving a minimum field. This means that we have a steep gradient of field in the region of x.

The resultant field is mapped in Fig. 4. A head which produces such a field has certain advantages over conventional heads for magnetic recording:

1. The field falls off more sharply as the record leaves the gap. This improves the resolution and minimizes "recording demagnetization."[3]

2. In a direction away from the pole pieces, the field changes less rapidly, giving more uniform magnetization through the thickness of the record, and less variation due to poor contact between head and record.

3. The field at the right-hand pole edge is more nearly longitudinal.

4. The main recording head operates at lower flux density.

5. The shape of the resultant field can be controlled by varying its components.

Figure 5 is a photograph of an early X-field head with taps to allow adjusting the relative number of turns on each of the legs. The auxiliary pole piece overhangs the head proper and is spaced about 15 mils above it, which gives clearance for threading and for splices in a 2-mil tape. Figure 6 shows typical connections for this head.

Test Results

To measure the improvement resulting from the cross field, the head was first tried with the center coil disconnected, so that it functioned as an ordinary head. Output vs. input curves were then run at 10,000 cycles, using the bias at which maximum possible undistorted output level occurred. Then

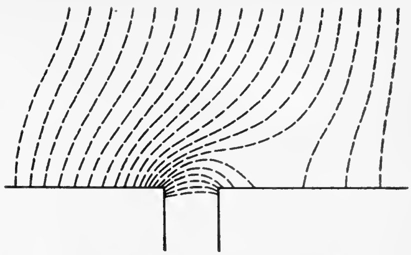


Fig. 4. Resultant of gap field and X-field.

the cross-field coil was connected, and adjustment was again made for maximum undistorted 10,000-cycle output. The results are given in Fig. 7, and indicate a $4\frac{1}{2}$-db advantage for the X-field connection, which means that about 65% more flux can be recorded at the high frequency on the same tape.

It is well known that when supersonic bias is increased beyond a certain rather critical value, the high-frequency response of a recording system goes down rapidly. The best explanation for this effect is that partial erasing of the short wavelengths occurs in the extended field of the recording gap (see "recording demagnetization"[3]). On the other hand, for distortionless low-frequency recording, we need enough bias to excite the recording layer through its entire thickness, and this turns out to be considerably more than for optimum high-frequency response. The result is usually a compromise in which the high frequencies suffer.

Bias requirements of the new head were determined both with the conventional and with the X-field connections. Results are shown in Table I.

Table I.

Connection	Bias required for undistorted 100-cycle output	Bias for max. 10-kc output	Loss at 10 kc due to increased bias
Standard	1000 ma	600 ma	7 db
X-field	650 ma	560 ma	0 db
X-field	(Purposely overbiased to 1000 ma)		1.5 db

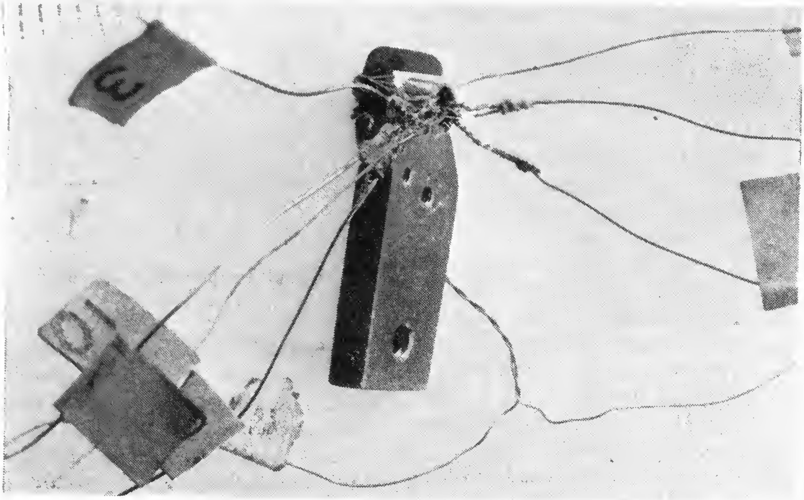


Fig. 5. Experimental X-field head.

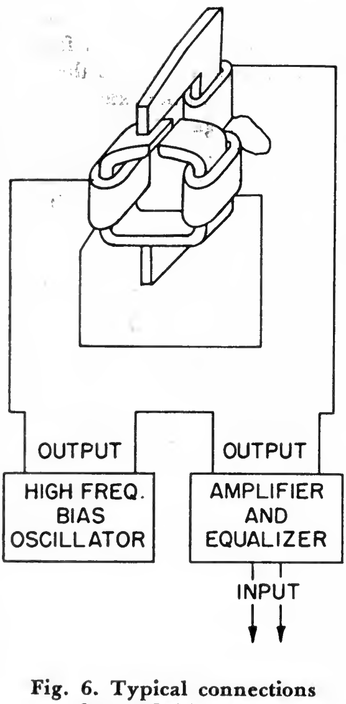


Fig. 6. Typical connections for X-field head.

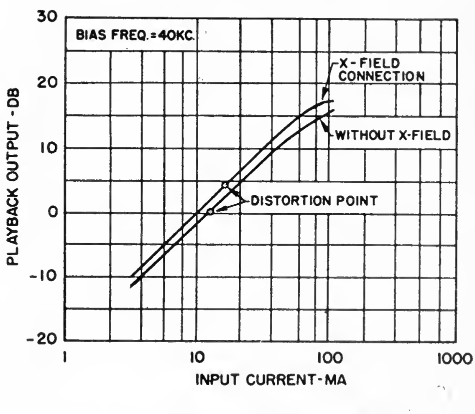


Fig. 7. Output-input curves for head at 10 kc.

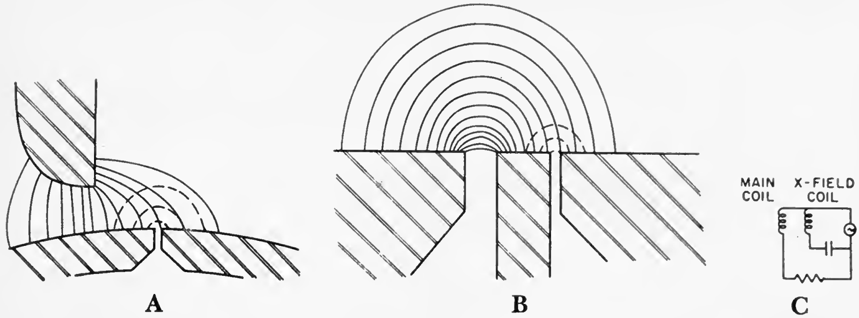


Fig. 8. Modified X-field head designs: (A) Effect of moving X-field pole piece to the left; (B) Double gap X-field head; and (C) Circuit for producing a rotating field at recording gap.

We note that bias requirements for the X-field head are practically the same for the high and low frequencies, and overbiasing has little effect. If the tests of Fig. 7 are conducted on a practical basis of optimum bias for low frequencies in each case, rather than bias for maximum 10-kc output, the advantage of the X-field head is even greater.

Variations

Some variations in the X-field head are shown in Fig. 8. In Fig. 8A the overhanging pole piece has been moved to the left. This tilts the cross field from the vertical direction and causes better cancellation of the gap field at the trailing edge. Also, the cross field decreases in intensity as we move to the right, so that it has less effect on the record beyond the cancellation point. The intense vertical field at the left of the record gap can be used for erasing, and its intensity may be increased still further by sharpening the pole piece. Or if we run the tape backward and make appropriate adjustments, this head becomes an efficient vertical recording head.

Figure 8B shows a head that has advantages of the previous one, but dispenses with the overhanging pole piece. Two gaps on the same side of the recording head are spaced closely enough together so that the right-hand part of the field produced by the large gap acts as a cross field for the small recording gap. The large gap may be used for erasing. In this connection, we found that by using audio in the main field only, but retaining the X-field principle for bias, excellent performance was obtained with this very simple design of erase-record head.

Figure 8C is a circuit which shows the degree of control possible with the X-field head. Here we use a condenser of relatively high reactance in circuit with the X-field coil to give a current 90° ahead of the voltage. A resistor in the recording coil circuit gives a current in phase with the voltage. The result is a head which provides a rotating bias field. Similarly, we can produce a rotary signal field or even a rotary erasing field.

We have found that although the primary advantages of the X-field head are in recording, there are also advantages in playback, since a reciprocal magnetic relation holds.

Conclusions

The field of a recording head gap can be modified to advantage by combining it with a cross field.

An X-field head has better resolution,

and a more ideal bias adjustment than an ordinary head.

Modified designs of X-field heads are as simple to manufacture and to use as conventional heads.

References

1. S. J. Begun, "Magnetic field distribution of a ring recording head," *Audio Eng., 32:* 11–13, 39, Dec. 1948.
2. R. Herr, B. F. Murphey and W. W. Wetzel, "Some distinctive properties of magnetic-recording media," *Jour. SMPE, 52:* 77–87, Jan. 1949.
3. O. W. Muckenhirn, "Recording demagnetization in magnetic tape recording," *Proc. IRE, 39:* 891–897, Aug. 1951.

Discussion

Anon: Can you tell us what the channel width was about?

Marvin Camras: This was done with an eighth-inch wide channel on quarter-inch tape.

Anon: Would the same results be obtained with 35mm magnetic film?

Mr. Camras: I don't see why the medium would affect the result. I think it would be substantially the same.

Anon: Do you still find the same variations in output of low frequency with this new type of head as you do with the normal-type head; the change of amplitude with frequency at about 100 cycles?

Mr. Camras: You mean the bumps in the response curves? As I remember, I don't think it had very much effect on that. That's caused by something else.

Anon: I know, but the changing of the contour of the field might affect that. As a matter of fact some of those bumps are likely playback effect, and if you use conventional playback heads it wouldn't change.

M. G. Townsley: When you use a cross-field head for record, you improve resolution on the film and the improved results are on the film. You said something very briefly about using a cross-field head for playback. What type of a cross field do you put on the head when you are using it as a playback head?

Mr. Camras: Of course, in a playback head you are just picking up fields, using it as a sensitive element for picking up something that's recorded. By using it for playback I meant that we used the cross-field coil and left it connected in the circuit during playback. We haven't run exhaustive tests and I haven't shown any results here of what it can do, but it seems to give us advantages in playback.

Mr. Townsley: In other words you make a fairly large gain. Suppose you use a head like this as a combined record playback head, you'd make a fairly large gain in record and a small further gain in playback?

Mr. Camras: Yes, I would say that. You're utilizing the material throughout the thickness of the layer to better advantage than you are with the conventional head that operates on one side of the record.

Mr. Townsley: The cross field so to speak is induced by the tape material itself as it passes over the head if you've got a double gap, for example, as you showed in the last picture.

Mr. Camras: I don't think I understand.

Mr. Townsley: I don't either.

Mr. Camras: Those gaps incidentally are very close together, just a few mils apart; and in that case you might get additional reinforcement or pickup of low frequencies with your second gap. If you try to work such a scheme with conventional double-gap heads where the record gap may be spaced a hundred mils or more from the erase gap you'd get bad echo effects, of course.

Mr. Townsley: It would seem to me that you might, with the gap space closer together, get some interference cancellation effects at fairly high frequencies, because of the phasing.

Mr. Camras: I haven't noticed those things. One gap is considerably larger than the other, at least ten times as large.

Push-Pull Direct-Positive Recording—An Auxiliary to Magnetic Recording

By LESLIE I. CAREY and FRANK MORAN

This paper explains the transferring of magnetic film from the daily okayed production takes to push-pull direct-positive film. By using a protective coating on the sound track, the cutting-room hazards are reduced 90%. This coating can be "peeled off" just before dubbing, assuring a new clean track from which to dub.

The advantages of using direct-positive records as a part of a magnetic recording program have been previously described by Loren L. Ryder in the Journal.[1] The records mentioned by Mr. Ryder are of the variable-density direct-positive type, utilizing the supersonic bias previously described.[2] The purpose of this paper is to describe the use of variable-area double-width push-pull records as an adjunct to the magnetic-recording program now in use at Universal Studios.

The difficulties involved in editing magnetic film and the expense involved in cutting it for dubbing purposes suggested the need of a medium which is inexpensive and, at the same time, capable of giving quality comparable to that obtained from magnetic films. In the opinion of the authors, the 200-mil variable-area double-width push-pull track adequately fulfills these requirements. The double-width track was selected because of its advantage over a single track, from a signal-to-noise standpoint, and the push-pull feature, as described below, was selected because of the lack of critical processing problems and improved signal-to-noise ratio. Direct-positive was selected because it eliminates the need for a negative record with its accompanying processing expense and printing losses.

The underlying principles involved in making a direct-positive record with the light valve have been described in the Journal.[3] The double-width push-pull variable-area track is obtained by applying a signal to the center ribbon and noise reduction to the two outside ribbons of a three-ribbon variable-area light valve.[4]

In order to obtain the type of track under discussion, a standard Western Electric RA-1231 Type Recorder,[5] equipped to record either a single- or double-width variable-area negative track, was modified to incorporate the direct-positive feature. No major changes were made in the film-pulling mechanism of this recorder, with the exception that facilities were provided so that the recorder could be run either in the normal forward or in a reverse

Presented on May 4, 1951, at the Society's Convention in New York, by Leslie I. Carey and Frank Moran, Universal-International Pictures, Universal City, Calif.

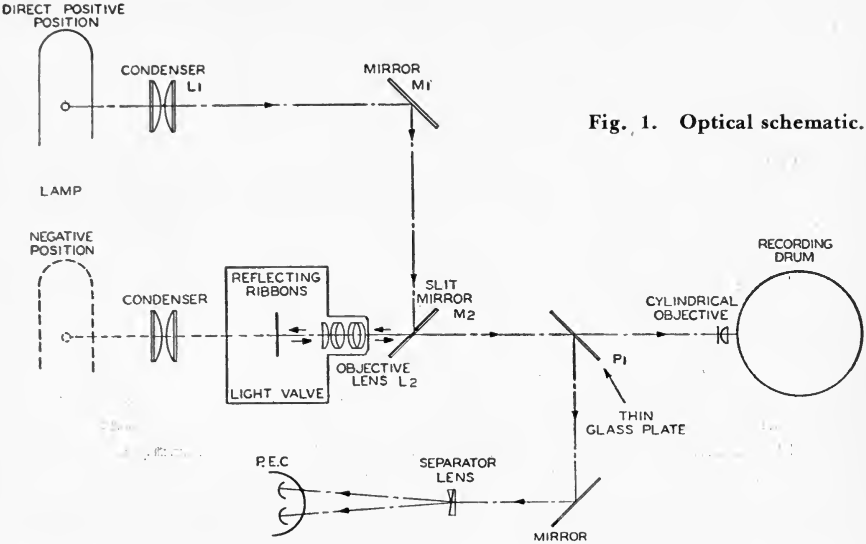


Fig. 1. Optical schematic.

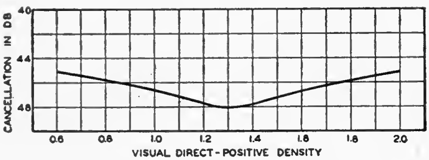


Fig. 2. Cross modulation characteristic.

direction. This permitted the recording of the normal negative track in the regular forward position, and the direct-positive track by the simple process of reversing the direction of the film during recording to eliminate the necessity of changing the position of the light valve. The studio has found it convenient to use a synchronous motor with the recorder on all occasions except for dubbing when, of course, the interlock motor is essential. In order to make both these drive facilities readily available, the recorder was equipped with two drive motors — one synchronous and one interlock — coupled through a single shaft to the drive mechanism. Either motor could then be selected by a simple switching arrangement.

The changes incorporated in the optical system to obtain the direct-positive type of track are noted below.

The Western Electric RA-1247 Three-Ribbon Light Valve[4] was restrung with reflecting surface ribbons. The optical system of the modulator was modified, as shown schematically in Fig. 1, so that the direct-positive type of record is obtained with the light source in the upper position. In this position the light passes through the condensing lens, L1, to a mirror, M1, where it is deflected downward to the slit mirror, M2. The latter directs the light through the objective lens, L2, in the light valve onto the reflecting ribbons. The light reflected by the ribbons is returned through the slit in the slit mirror, thence through a clear-glass plate, P1, and through the objective lens to the film. The clear-glass plate reflects a small percentage of the recording beam back to the photocell for PEC monitoring.

The double-width push-pull track offers two distinct advantages over the standard track, first, by virtue of the extra width, an improvement in the signal-to-noise ratio and, second, the push-pull feature offers low and rela-

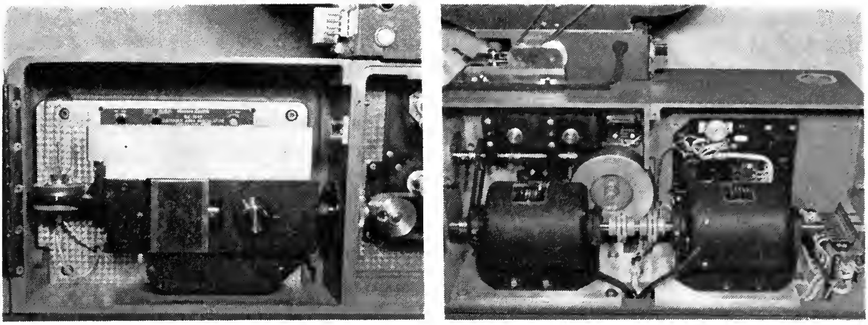


Fig. 3. Direct-positive recorder. Left: rear view. Right: front view.

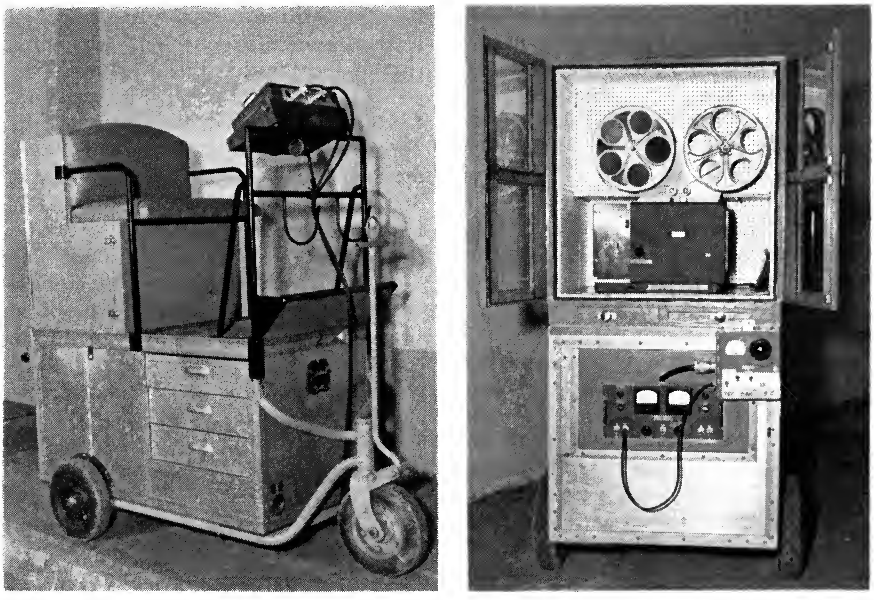


Fig. 4. Magnetic channel. Left: front view. Right: rear view.

tively constant cross-modulation products over a large range of densities (Fig. 2). The latter feature greatly simplifies the processing problems which are normally encountered on tracks which do not have the push-pull feature. For example, a track density of 1.8 on Eastman Kodak Emulsion 5372 was found to be completely feasible. When this is compared to a "balance" density around 1.3 for a single track on the same emulsion, the advantages of increased signal output and reduced grain noise are immediately evident.

The 200-mil push-pull variable-area method of recording was put into service at Universal Studios on January 10, 1951, on the production *The Iron Man*, and subsequently on a musical short, *Ziggy Elman and His Orchestra.* It is currently being used on the production *Fiddlers Green.* All original takes are being made

on 35mm sprocket-hole-type magnetic film and at the end of a day's work all "print" takes are transferred to direct-positive. In this way the magnetic film becomes the "negative" and is stored intact until the picture is released, at which time it will be erased and available for future productions. The direct-positive track now serves as the "daily" sound track and eventually, after editing and cutting, as working and dubbing prints.

The quality of sound obtained through the magnetic-direct-positive procedure is noticeably superior to and more dependable than that obtained with the regular photographic process. A careful check has indicated that very little noise is introduced as a result of running for the "dailies" and during handling in the cutting process.

Not only does the use of magnetic-direct-positive system improve the overall sound quality of a production, but economies in the cost of film and film processing are realized at the same time. While exact figures are not yet available, approximate relative costs between the regular photographic process and the magnetic-direct-positive process have been estimated on *The Iron Man* production. A total of 104,000 ft of recording was made on this production. Actually 52,000 ft of magnetic film were used with separate tracks at either edge of the 35mm film. One half, or 29,000 ft, of this recording represented "print" takes which were transferred to direct-positive. If this production had been originally recorded on a photographic negative, from which working prints were to be made, a total of 104,000 ft of negative stock, plus 29,000 ft of positive stock, plus the negative and positive processing cost would have involved an expense of approximately $4100. As the production was actually recorded first on magnetic film and then with the "print" takes transferred to direct-positive, 29,000 ft of direct-positive stock plus its processing involved a cost of approximately $884. The initial investment in 52,000 ft of magnetic film is approximately $2080. However, inasmuch as this film can again be used after erasure, only a portion of the cost should be applied against this production.

Sufficient time has not yet elapsed to make a sound determination of the life of the magnetic film, inasmuch as some of the stock obtained at the beginning of our magnetic program three years ago, and used frequently since that time, is still in good condition. If it is assumed conservatively that the stock can be used 25 times, the cost per production is then approximately $84. The total cost of the film together with the processing of the direct-positive is, therefore, $884 plus a prorated cost of $84 for the magnetic film, or a total of $968, as against $4100 for the negative-positive method, or a saving of approximately $3132 per production.

The use of the push-pull variable-area direct-positive recording as an adjunct to the magnetic recording program at Universal Studios has proven to be completely successful from the standpoint of simplifying and cutting the cost of the recording operations, as well as retaining the high quality of the original magnetic recordings.

References

1. Loren L. Ryder, "Motion picture studio use of magnetic recording," *Jour. SMPTE, 55:* 605–612, Dec. 1950.
2. C. R. Keith and V. Pagliarulo, "Direct-positive variable-density recording with the light valve," *Jour. SMPE, 52:* 690–698, June 1949.
3. Lewis B. Browder, "Direct-positive variable-area recording with the light valve," *Jour. SMPE, 53:* 149–158, Aug. 1949.
4. John G. Frayne, "Variable-area recording with the light valve," *Jour. SMPE, 51:* 501–520, Nov. 1948.
5. G. R. Crane and H. A. Manley, "A simplified all-purpose film recording machine," *Jour. SMPE, 46:* 465–474, June 1946.

Proposed Standard Enlargement Ratio for 16Mm to 35Mm Optical Printing

Efforts to reduce costs in color cinematography have led, in the past few years, to an appreciably increased commercial use of 16mm film as original negative for 35mm release prints. Optical enlargement printing is, of course, an essential factor in this process. A standard magnification ratio thus becomes a necessity since the difference in aspect ratios of the two film sizes precludes the simple use of the 35/16 ratio.

The Laboratory Practice Committee, chaired by John Stott, tackled the problem in February 1951; a first draft was submitted by Gordon Chambers in May 1951 and approved by the Committee a few months later. A revised draft was subsequently approved for publication by the Standards Committee and is published on the following page for a 90-day period of trial and criticism.

Please forward any comments, in duplicate, to Henry Kogel, Staff Engineer, at Society headquarters, by April 15, 1952.

Proposed American Standard

Enlargement Ratio for 16Mm to 35Mm Optical Printing

PH22.92

In the enlargement printing of 16mm film to 35mm film, a magnification of 2.21 ± 0.01 shall be employed and the center of the 16mm frame as enlarged shall coincide with the center of the 35mm aperture in the enlarging printer.

This will mean a scanned area on the 16mm frame of 0.272 inch ± 0.002 × 0.373 inch ± 0.002 will be projected through the 35mm projector aperture when the print is used in the theater. This corresponds to a frame of 0.284 inch × 0.380 inch if the 16mm original were projected directly.

The scanned area of the 16mm frame in the printer as enlarged to the 35mm camera aperture is 0.286 inch ± 0.002 × 0.393 inch ± 0.002.

Attention of camera users is invited to the desirability of using a camera finder matte 0.272 inch ± 0.002 × 0.373 inch ± 0.002 when exposing 16mm film to be enlarged to 35mm film.

Note: In enlargement from 16mm positive or reversal original to 35mm negative a black frame line will result on the final 35mm print. In the case of enlargement from 16mm negative directly to 35mm print, white frame lines will result. If the height of the 16mm aperture for enlargement from 16mm negative to 35mm print is made 0.300 inch, the resulting aperture image on the 35mm print will be from 0.660 to 0.666 inch in height. While the frame line will not be entirely black, there would be a black margin on either side of the image which would give an additional safety factor in projection.

NOT APPROVED

71st Semiannual Convention

The Spring Convention has for many weeks been in the minds and work of those generally responsible for conventions and of those especially responsible for the Chicago Convention, April 21–25, at The Drake.

Bill Kunzmann has already spent a good deal of time in Chicago and has done all the groundwork of planning with The Drake and also already has a roster of chairmen for the dozen major activities and functions throughout the convention. The complete roster will be published in the February *Journal.*

John Frayne, at an editorial meeting during the Hollywood Convention, appointed as Program Cochairmen **R. T. Van Niman** and **George Colburn.** They and others are already at work on the papers program under direction of Papers Committee Chairman **Ed Seeley.** Manuscripts and suggestions should go promptly to any of the Papers Committee, listed below; but all manuscripts and authors' forms (these are available from members of the Committee or from Society headquarters) should reach Cochairman George Colburn, 164 N. Wacker Drive, Chicago 6, Ill., as soon as possible.

John Frayne also confirmed at the Hollywood editorial meeting the choice of **Richard O. Painter** to be Vice-Chairman for High-Speed Photography for Chicago. In addition to the planning of at least two high-speed photography sessions, the editorial meeting and subsequent planning have evolved the following tentative schedule of session subjects: two sessions on 16mm; one on sound recording; three or four sessions on television; one on laboratory problems; and one general session.

C. E. Heppberger, Secretary-Treasurer of the Central Section, has the very important duties of Local Arrangements Chairman. He put out a solid two-page memo in late November to begin tying together the long roster of all the arrangements he must be sure about.

PAPERS COMMITTEE

Chairman: **Edward S. Seeley,** Altec Service, 161 Sixth Ave., New York 13

71st Convention Program Cochairmen: **R. T. Van Niman** and **George W. Colburn.** *Address manuscripts and authors' forms to George Colburn, 164 N. Wacker Drive, Chicago 6, Ill.*

Vice-Chairmen

For New York: **W. H. Rivers,** Eastman Kodak Co., 342 Madison Ave., New York 17

For Washington: **J. E. Aiken,** 116 N. Galveston St., Arlington, Va.

For Los Angeles: **F. G. Albin,** Station KECA-TV, American Broadcasting Company Television Center, Hollywood 27, Calif.

For Canada: **G. G. Graham,** National Film Board of Canada, John St., Ottawa, Canada

For High-Speed Photography for Chicago: **Richard O. Painter,** General Motors, Proving Ground Section, Milford, Mich.

Committee Members

A. C. Blaney, RCA Victor Div., 1560 N. Vine St., Hollywood 28, Calif.

Richard Blount, General Electric Co., Nela Park, Cleveland, Ohio

R. P. Burns, Balaban & Katz, Great States Theaters, 177 N. State St., Chicago 1, Ill.

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Howard Chinn, Columbia Broadcasting System, 485 Madison Ave., New York

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E. W. D'Arcy, De Vry Corp., 1111 W. Armitage Ave., Chicago 14, Ill.

Farciot Edouart, Paramount Pictures Corp., 5451 Marathon St., Hollywood 38, Calif.

F. L. Eich, Paramount Film Laboratory, 1546 Argyle Ave., Hollywood 28, Calif.
Dudley Goodale, National Broadcasting Co., 30 Rockefeller Plaza, New York 20.
Charles Handley, National Carbon Div., 841 E. Fourth Pl., Los Angeles 13, Calif.
R. N. Harmon, Westinghouse Radio Stations, Inc., 1625 K St., N.W., Washington, D.C.
Scott Helt, Allen B. Du Mont Labs., Inc., 2 Main Ave., Passaic, N.J.
C. E. Heppberger, National Carbon Div., 230 N. Michigan Ave., Chicago 1, Ill.
J. K. Hilliard, Altec Lansing Corp., 1161 N. Vine St., Hollywood 38, Calif.
L. Hughes, Hughes Sound Films, 21 S. Downing St., Denver, Colo.
P. A. Jacobson, University of Washington, Seattle, Wash.
William Kelley, Motion Picture Research Council, 1421 N. Western Ave., Hollywood 27, Calif.
E. P. Kennedy, Signal Corps Labs, Fort Monmouth, N.J.
George Lewin, Signal Corps Photographic Center 35–11 35 St., Long Island City 1, N.Y.
E. C. Manderfeld, Mitchell Camera Corp., 666 W. Harvard St., Glendale 4, Calif.
Glenn Matthews, Research Laboratory, Eastman Kodak Co., Rochester 10, N.Y.
Pierre Mertz, Bell Telephone Labs., Inc., 463 West St., New York 14
James Middlebrooks, American Broadcasting Co., 30 Rockefeller Plaza, New York 20
Harry Milholland, Allen B. Du Mont Labs, Inc., 515 Madison Ave., New York 22
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Edward Schmidt, Reeves Soundcraft, 10 E. 52 St., New York 22
N. L. Simmons, Eastman Kodak Co., 6706 Santa Monica Blvd., Hollywood 38, Calif.
S. P. Solow, Consolidated Film Industries, Inc., 959 Seward St., Hollywood 38, Calif.
J. G. Stott, Du-Art Film Laboratories, 245 W. 55 St., New York 19
W. L. Tesch, Radio Corporation of America, RCA Victor Div., Front and Cooper Sts., Camden, N.J.
S. R. Todd, Consulting Electrical Engineer, 4711 Woodlawn Ave., Chicago, Ill.
M. G. Townsley, Bell & Howell, 7100 McCormick Rd., Chicago 45, Ill.

Discussions in the Journal

Discussions are a valuable part of the Society's functioning. Those which occur on the floor at Conventions are now recorded as described in Ed Templin's Committee Report in the December *Journal.* The procedure and policy, once discussion is on a disk, are:

Headquarters staff transcribes it almost verbatim, pausing to correct only the most obvious verbal slips. The typewritten transcript is sent to the author, usually at the time his paper is being processed for *Journal* publication. Depending on the length and clarity of the discussion, the transcript is sent simultaneously or successively to all discussers. Whatever the timing, however, **discussion is sent to all persons named in the record and they must clear it before it is published.** What worthy discussion cannot be identified as to source becomes that of Mr. Anon.

Within a month after the close of the Hollywood Convention, the Society's staff had transcribed 105 pages of discussion from that program.

In addition, 48 pp. have been transcribed and mimeographed as the record of the Panel Discussion on Emulsion Position of 16Mm Positives. This has been sent to all known interested persons. Let headquarters know if you are interested and were overlooked. A copy will be sent to you. When everyone interested has returned his panel or subsequent discussions to Society headquarters, a composite copy will be made for review by Norwood Simmons, who was moderator of the panel discussion, and it will then be assessed for *Journal* publication.

Engineering Activities

Three meetings of interest were held recently, only one of a Society engineering committee. The highlights of these meetings are outlined below.

PH22 Led by its new Chairman, D. R. White, ASA Sectional Committee on Standards for Motion Pictures, PH22, met November 29, 1951, and had a very fruitful session with an agenda limited to three key items.

Letter Ballots: Three letter ballots were considered and acted upon:

1. Two proposed standards for 35mm multifrequency test films, PH22.63 and PH22.64, held in abeyance for some time as a result of a major consumer's negative vote, were returned to the Sponsor for resolution of the existing differences.
2. A proposed revision of the standard for 16mm reels, PH22.11, was approved and forwarded to the Sponsor.
3. The ballot on the 16Mm Edge Numbering Proposal, PH22.83, was incomplete and the Chairman was authorized to close the ballot at his own discretion.

ISO: Questions relating to a contemplated meeting of ISO TC/36 (International Standards Organization Technical Committee on Cinematography) in New York in June 1952 were thoroughly reviewed. It was decided to canvass the participating members concerning their interest in attending such a meeting, informing them of our willingness to call one if there is promised attendance from abroad. (The ASA, Secretariat of TC/36, subsequently sent a modified version of a letter drafted by PH22.)

PH22 Scope: The new scope, endorsed at the last meeting, was criticized in the interim as excessively broad and two alternate proposals were offered for Committee consideration. A compromise between the two was approved as the Committee recommendation to the SMPTE, which as Sponsor, has the final word on the scope to be submitted to the ASA.

IRS The IRS was formed in April 1950 as a coordinating committee of three Societies (IRE, RTMA, SMPTE) to eliminate or reduce duplication of work and areas of conflict in mutual spheres of activity, primarily in the field of television. Originally chaired by Axel Jensen and now by Fred Bowditch, the Committee met November 30 and December 20, 1951, to consider two main points.

Committee Addition: In the light of NARTB's renewed interest in standards activity, discussions were held as to the advisability of including it as a fourth member. After an affirmative vote at the first meeting, the NARTB was officially welcomed as a Committee member at the December meeting.

Recording Standards: CCIR's (International Radio Consultative Committee) program for standardizing radio program recordings for use between nations was outlined and the need for American Standards on sound recording was reviewed. The Committee concluded that the ASA Sectional Committee on Sound Recording, Z57, should be reactivated and proposed the procedure for achieving this.

New Name: The addition of a fourth member required a change in the IRS Committee name which was compounded from the first initials of the three participating Societies. "Joint Committee for Inter-Society Coordination," to be abbreviated "JCIC," won the day and is the new name of the Committee.

Television Studio Lighting Since its inception in January 1950 under the chairmanship of Richard Blount, this Committee has met about every three months. The Chairman noted, however, that very little has been accomplished this past year. The main discussion then centered on the cause of this situation and how to remedy it.

This very practical approach resulted in changes both in form and content of the Committee's work with accompanying changes in project responsibilities. Small subcommittees were eliminated and the entire Committee is to concentrate its attention on two main projects: lighting measurements and terminology.—*Henry Kogel*, Staff Engineer.

Book Reviews

Three-Dimensional Photography: The Principles of Stereoscopy

By Herbert C. McKay. Published (1951) by American Photographic Publishing Co., 421 Fifth Ave. So., Minneapolis 15, Minn. 334 pp. 98 illus. 6 × 9 in. Price $5.75.

Herbert C. McKay, FRPS, ASC, well known to readers of *American Photography* for his monthly column "Notes from the Laboratory" and for his observations on developments in photography and comments on stereoscopy, has compiled a text that is of interest to amateur photographers but it's hardly a book that has much appeal to professional photographers or serious stereographers. Some of the theories on which the principles of stereoscopy are based are blithely ignored, some are attacked. It certainly is not to be recommended as a reference work for any motion picture engineer interested in the stereoscopic process.

The author preaches such adroit doctrines as: "It has been repeatedly demonstrated that a beginner knowing nothing whatsoever about photography will have a greater success in stereo than in conventional photography"; and " . . . the fact remains that the gravest trouble encountered by projectionists in the stereo field is the result of taking too much care."

The inference, to me at any rate, is that knowledge of stereoscopic theory, skill in photography, and careful craftsmanship are handicaps rather than helps in the stereoscopic art.

To sustain the mood, the author, in referring to the projection of stereo slides has this to say, " . . . You drop the stereogram in the projector and enjoy it. The headaches have all been removed. There is nothing more than this that is absolutely essential." Then, in taking stereograms of close objects, "Some stereographers erroneously use a narrow base when making any stereogram nearer than ten feet."

He evidently means that if you're photographing a flower at a distance of 2½ ft with the normal base (lens interaxial) of 2½ in. and there is not provision on the camera for converging the field of each lens to a plane 2½ ft away or nearer you'll come out with a perfectly good stereogram. This conflicts with some of the basic theories of stereoscopy.

To quote the author again: "Those who have seen modern stereo projection, now predict that stereo movies will soon be developed; they do not know that stereo movies were presented in a Broadway theatre a quarter century ago, and in many other theatres throughout the land. They do not know that polarized light stereo movies were featured at both the Chicago (1933) and New York (1939) World's Fairs. There is little to be done in that field, it has all been done time after time and any amateur can with a minimum of ingenuity make his own stereo attachments which will enable him to project perfect stereo movies." It will interest all to know that "There is little to be done in that field, it has all been done time after time . . . . " And, that anyone with a minimum of ingenuity can make and project *perfect stereo movies.* I'm afraid it takes just a bit more doing than Mr. McKay seems to indicate.

But let's have some more light on the subject from the author: " . . . we have not emphasized the distinction between motion pictures and still projection, for one very good reason. Optical projection remains the same no matter whether the projected images are changed twenty times a second or twenty times an hour. A system which will work with one, will, with few exceptions work with the other." This reviewer and his associates have been concentrating through the years on these "few exceptions," to the exclusion of the seemingly more direct and simpler methods. All serious workers in cinestereoscopy must take into consideration the problems of uneven illumination, differential vibration between members of the stereoscopic pair and other things that can detract from complete visual comfort for the audience viewing three-dimensional motion pictures.—*J. A. Norling*, Loucks and Norling Studios, 245 W. 55th St., New York 19.

The Indian Film

By Panna Shah. Published by I. K. Menon and the Motion Picture Society of India, Sandhurst Bldg., Sandhurst Road, Bombay 4, India. 289 pp. incl. 22 pp. of appendix, bibliography and index. 20 illus. $5\frac{1}{2} \times 8\frac{1}{2}$ in. Price Rs. 10/-.

Dr. Panna Shah has put film makers both of the East and the West very much in her debt by this searching study of the conditions of the motion picture industry in her native country. Thoroughly versed in the film literature of the western world, Dr. Shah has a useful yardstick for measuring Indian accomplishments. The conditions she reveals are indeed depressing. In chapter after chapter she castigates Indian producers, distributors and exhibitors alike for the poor quality of Indian films and the wretched conditions under which they are shown. Yet her criticisms are not merely destructive. It is evident that they are inspired by a strong and sincere wish to see indigenous Indian films of high quality achieve success in India itself and spread a greater knowledge of India to the rest of the world.

Though vital statistics of the Indian industry are seemingly scanty and inaccurate, Dr. Shah collates them to the best possible effect to show a state of affairs resembling that of the U.S. industry some thirty years ago, when bankruptcies, ever-changing amalgamations and sudden standstills of production were prevalent. Nor are these conditions surprising in a country where so high a proportion of the population lives in the villages, which are seldom or never reached by films. And there are the further limitations of multiplicity of languages and tremendous differences of taste and cultural background.

The history of the Indian film is thoroughly covered, and there are chapters on Indian film stars, on audiences, on censorship, on mythology, and on the social influence of films, which is evidently the author's particular field of study. This is a book which all should read who wish to learn more about the second largest film industry in the world.—*Raymond Spottiswoode*, Kingsgate, Sudbury Hill, Harrow-on-the-Hill, Middlesex, England.

The Film Industry in Six European Countries

By Film Centre, London. Published (1950) by Unesco, Paris; U.S. sales agent, Columbia University Press, 2960 Broadway, New York 27. 156 pp. Many tables. $5\frac{3}{8} \times 8\frac{3}{8}$. Paper covered. Price $0.65.

This is one of the series "Press, Film and Radio in the World Today" which Unesco is publishing in following out its constitutional obligation to "further by all possible means the use of the instruments of mass communications in the work of advancing the mutual knowledge and understandings of peoples."

Beginning on the strong basis of a Danish report "Betaenkning . . . angaende Biografvaesenet" published in 1950, a detailed study and comparison are developed for the other two small countries, Norway and Sweden, then chiefly a statistical study is presented for Italy, France and the United Kingdom. Making Denmark the special part of this study is logical enough when the facts are in on the Danish film industry: for instance, Denmark a country of only about 4,000,000 persons produces more films a year than Belgium, The Netherlands and Switzerland together. This small book has an amazingly large amount of text and statistics about costs and results in exhibition, distribution and production.—V.A.

Charlie Chaplin

By Theodore Huff. Published (1951) by Henry Schuman, 20 E. 70th St., New York 21. i-xi + 354 pp. + 80 pp. illus. 6×9 in. Price $4.50.

The filmic Charlie Chaplin is here given perhaps as well as he can now be portrayed in a book, unless a book were to contain even more than this volume's generous collection of 80 pages of illustrations. But of looking at stills there is soon an end, and we go back whenever possible, generation after generation the world over, to seeing Chaplin films. And how seldom we hear them referred to nowadays as "old" films.

For the many who would like to find out how old is each Chaplin film, this is an excellent reference. One appendix

gives biographical sketches of the people professionally associated with Chaplin; another appendix indexes thoroughly all the films: the Keystones in 1914, the Essanay Films of 1915–16, Mutual Films in 1916–17, the First National releases of 1918–22, and the seven released by United Artists in 1923–1947. Casts, release dates, length of films and other data are given.

There is considerable text which will varyingly inform or interest readers. Not only is the production of each film described but also there is given a frame of timely reference of general and film business conditions, international and domestic political factors, and, without being unnecessarily scandalous about it, an adequate notice of what was happening in the personal lives of those on or off the sets. If this is not a thoroughly knit and compact picture of the individual Chaplin, perhaps we can forgive the biographer at this time when it is doubtful if such could be accomplished even autobiographically. On one point, however, the author is clear: the artist Chaplin has ever been striving wholly and honestly to accomplish more and more with the film, to make each film somehow a greater accomplishment than the preceding one.

That Chaplin's success has been continual and consistent may properly be doubted by biographer and reader according to his own artistic taste. This book gives a solid basis for our understanding the peculiar qualities of Chaplin and his use of the film medium which led George Bernard Shaw to call Chaplin "the only genius in motion pictures."—V.A.

The Little Fellow

The Life and Work of Charlie Chaplin

By Peter Cotes and Thelma Niklaus. Published (1951) by Philosophical Library, 15 E. 40th St., New York 16. 160 pp. incl. 32 pp. illus. $5\frac{1}{2} \times 8\frac{3}{8}$. Price $3.75.

There is less about motion pictures in this book than in the book briefly reviewed above. There is much more of an effort by the coauthors to accomplish a psychological analysis of Chaplin's background, development and work. There is a deal of detail beginning generally with Chaplin's efforts to earn his way at the age of eight, then on through his growing artistic and financial successes. At the age of 11 he successfully achieved the part of Billy in *Sherlock Holmes* only by having his mother drill him with the script, for he had not yet learned to read or write.

The authors seem fairly occupied in setting consistently right the considerable record of matrimonial matters, of which the public may have an undue aftertaste from many doses of strong headlines and lurid inks. The explanations of why Chaplin's first three marriages were ill fated and his present one apparently the contrary are plausible and interesting enough; but the authors do not quite explain how anyone, genius or otherwise, could often create such unbelievably bad working conditions for himself and then accomplish the almost superhuman in completing the motion picture he wanted — but at other times to be the effective genius from the start in training and directing as in *The Kid*.—V.A.

Acoustical Terminology is American Standard Z24.1–1951 sponsored by the Acoustical Society of America in cooperation with The Institute of Radio Engineers. This latest edition was approved July 31, 1951, and is now available at $1.50 from the American Standards Assn., 70 E. 45th St., New York 17. A number of special committees worked to revise this standard since the first edition was published in 1942. The section on speech and hearing has been thoroughly revised to bring it into agreement with the most recent experimental results. Twelve sections, including six tables, and a thorough index make up this 50-page standard.

John Wiley & Sons, Inc., is revising its mailing lists and would appreciate receiving a postal with the proper address and an indication of your interest in scientific, technical or business books. Address: Miss Clotilda Lowell, John Wiley & Sons, Inc., 440 Fourth Ave., New York 16.

New Members

The following members have been added to the Society's rolls since those last published. The designations of grades are the same as those used in the 1950 MEMBERSHIP DIRECTORY.

Honorary (**H**) Fellow (**F**) Active (**M**) Associate (**A**) Student (**S**)

Archer, Nicholas M., University of Southern California. **Mail:** 5965¼ Chula Vista Way, Hollywood 28, Calif. (**S**)

Conner, Robert W., Director of Engineering, KLAC, KLAC-TV, 1000 Cahuenga Blvd., Hollywood, Calif. (**M**)

Hittle, C. E., Design Engineer, RCA Victor Div. **Mail:** 12544 Gilmore St., North Hollywood, Calif. (**A**)

Jewell, F. Irving, Director, Visual Education, National Council, Boy Scouts of America, 2 Park Ave., New York, N.Y. (**A**)

Kook, Edward F., President, Century Lighting, Inc., 521 West 43 St., New York, N.Y. (**M**)

Litecky, Paul A., Photographer, Cinematographer. **Mail:** 1306 Davis Ave., Whiting, Ind. (**A**)

Morris, Thomas C., Camera Operator, Jerry Fairbanks. **Mail:** 10552 Tinker Ave., Tujunga, Calif. (**A**)

Pierce, Cameron G., Television Engineer, American Broadcasting Co. **Mail:** 555 Old Mill Rd., San Marino, Calif. (**M**)

Pon, S., Salesman. **Mail:** Corner Best & Victoria Roads, Sophiatown, Johannesburg, South Africa. (**A**)

Reisinger, Carl H., Photographer, Freelance. **Mail:** 1417 Kalmia Rd., N.W., Washington, D.C. (**A**)

Rothenberger, Warren Jack, First Cameraman, Boy Scouts of America. **Mail:** 1543 Sidney Pl., East Meadow, L.I., N.Y. (**A**)

Spriestersbach, Charles L., Television Technician, KTTV. **Mail:** 15117 Germain St., San Fernando, Calif. (**A**)

CHANGES IN GRADE

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Carreau, Gerald, Engineer, Columbia Broadcasting System. **Mail:** 285 Avenue C, New York 9, N.Y. (**A**) to (**M**)

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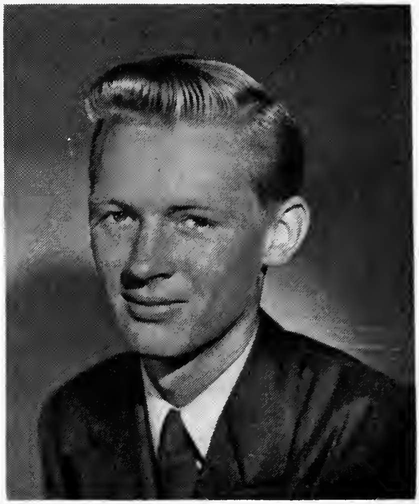
Melvin L. Stewart is the designer of the Society's new emblem which was adopted by the Board of Governors last October and described in the December *Journal.* The symbol appears on the cover of this issue of the *Journal* and it will gradually be made a part of the many Society communications. Mr. Stewart resides at 10326 Orton Ave., Los Angeles. He is a senior commercial design student at the University of Southern California, ranks high in his class and has received three scholarship awards. He has exhibited magazine cover designs, book jacket, fabric and wallpaper designs. He is 23 years of age and is the son of George M. Stewart who is employed in the Sound Department of Twentieth Century-Fox Film Corp., Beverly Hills, Calif.



New Membership Directory

A new directory will be mailed as Part II of one of the *Journals* late this spring. Plans are to organize it generally as was done in 1950 — unless members send in valid suggestions for a revised arrangement.

Each member should note that with his statement for dues for 1952 the Society sent a copy of his last listing brought up to date according to the Society's records at the beginning of December. In making the new directory, advice about changes in address or employment will be taken into account at least as late as March 3.

Meetings of Other Societies

American Physical Society, Annual Meeting, Jan. 31–Feb. 2, Columbia University, New York

Inter-Society Color Council, Annual Meeting, Feb. 7–9, Hotel Statler, New York

I.R.E. National Convention, Radio Engineering Show, Mar. 3–6, Hotel Waldorf Astoria and Grand Central Palace, New York

National Electrical Manufacturers Association, Mar. 10–13, Edgewater Beach Hotel, Chicago, Ill.

American Physical Society, Mar. 20–22, Columbus, Ohio

Optical Society of America, Mar. 20–22, Hotel Statler, New York

American Physical Society, May 1–3, Washington, D.C.

Acoustical Society of America, May 8–10, New York

American Institute of Electrical Engineers, Summer General Meeting, June 23–27, Hotel Nicollet, Minneapolis, Minn.

American Physical Society, June 30–July 3, Denver, Cclo.

Photographic Society of America, Annual Convention, Aug. 12–16, Hotel New Yorker, New York

American Institute of Electrical Engineers, Pacific General Meeting, Aug. 19–22, Hotel Westward Ho, Phoenix, Ariz.

Illuminating Engineering Society, National Technical Conference, Aug. 27–30, Washingtcn, D.C.

New Products

Further information about these items can be obtained direct from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of these items does not constitute endorsement of the products.

The Aminco Photomultiplier Microphotometer is a product of American Instrument Company, Inc., Silver Spring Md., designed for many applications including film densitometry. This instrument has ranges providing direct readings for intensities from 20 micromicrolumens to 20 lumens, densities from 0 to 9 and phototube currents from 10^{-5} to 10^{-11} amp which can be extended with neutral filters.

Full-scale deflection of the meter is given with photomultiplier (or phototube) currents of 10, 1, 0.1 and 0.01 μa. The latter value corresponds to a sensitivity of 20 micromicrolumens per meter division with photomultiplier tube detector No. 4-6250 which is supplied with the instrument. Commercial types of phototubes (blue, green, red and infrared) may be used by wiring them into an 11-prong base.

The American Instrument Company reports that it will supply filters from Baird, Bausch & Lomb, Corning, Eastman, Farrand or Fish-Schurman, which are 2 in. (50 mm) square and may be positioned in the filter holder, either singly or in combinations up to $\frac{5}{8}$ in. thick.

SMPTE Officers and Committees: The roster of Society Officers and the Committee Chairmen and Members were published in the April 1951 *Journal.*

A new professional camera dolly that will go through most standard doorways without being disassembled is being marketed by The Camera Mart, Inc., 70 W. 45th St., New York 19, under the trade name TV Camera Car. Equally useful in the motion picture industry, the Camera Car weighs 350 lb, is 30 in. wide, and provides lens angles from 26 in. to seven ft.

The dolly carries the cameraman and one assistant, and one man can maneuver it, either on or off dolly tracks. The two front wheels are set and the two rear wheels have an auto-linkage steering mechanism for maneuverability or sharp turns. Two floor locks steady the dolly for set shots, and boom arm braces are designed to prevent vibrations for extended dolly runs. The tripod head has two leveling finger-tip jacks for quick horizontal adjustment. In addition there is a vertical leveling rod attached to the boom arm, a necessity when setting for a side shot.

Four powerful removable springs and a cable are arranged to balance any weight camera and blimp. Raising or lowering the boom arm is accomplished by turning the large counter-balanced wheel and attached gears. The dolly is constructed of aluminum alloy castings with bridge supports for greater strength and flexibility, and with 10-in. ball-bearing rubber-tired wheels.

With the boom in a horizontal position, the dolly may be lifted into a station wagon for easy transportation. In addition, in 20 min it may be disassembled into its three main parts and carried on a location where the areas are too confined to admit it otherwise. Reassembling then takes approximately 30 min. This is considered an especially valuable feature when shooting on locations in old buildings with narrow stairways or no elevators. The Camera Car is priced at $1,495 FOB New York.

Westrex 1100 Series Magnetic Recording System

Correction and amplification: Running back to the November 1951 *Journal*, p. 510, we should now record that the above illustrates the 1100 Series Portable Magnetic System now being introduced to the industry by Westrex Corporation. The rest of the record is now played back for your convenience:

The 1100 Series Portable Magnetic System now being introduced to the industry is a direct outgrowth of field experience with the earlier 1000 Series System previously described in the *Journal* for March 1951. The number of cases has been reduced to two as shown in the photograph, the two-position mixer being on the right and the recorder being on the left. The latter houses, in addition to the film pulling mechanism, the a-c power supply for the channel, the bias oscillator and the film monitor amplifier.

New features of this system include two-way talkback equipment between the mixer and recordist, a talkback amplifier being provided in the recorder housing. Another new feature is a synchronizing bloop unit which records an audible signal when the recorder is up to speed on the magnetic film in synchronism with an optical bloop in the associated photographic camera.

The system operates from 115 v, single-phase, 50- or 60-cycle a-c supply, provision being also made for motor operation from 220 v, 3-phase, interlock or multi-duty motor systems. Runback at normal speed is provided. The power drain for the electronic components is somewhat less than 100 w and a 2-amp drain at 115 v is required for the single phase motor supply.

The weight of the complete system, including cables, is approximately 170 lb. The system is available for 35mm, 17½mm or 16mm operation. The track positions are in accordance with the proposed ASA magnetic track standards for 35mm and 16mm films. The recorder may also be used as a magnetic film reproducer, equalization being provided in the playback amplifier to give an essentially flat response from 50 to 8000 cycles when operating at 90 ft/min. By incorporating some pre-emphasis in recording on 16mm film, a flat response to 6000 cycles may be obtained at the 16mm speed of 36 ft/min.

Factors Affecting the Quality of Kinerecording

By P. J. HERBST, R. O. DREW and J. M. BRUMBAUGH

Limitations imposed by television and photographic processes, employment of electrical compensation for degradations in detail and contrast rendition, with experimental investigation of various aspects of the system, are reviewed. Conclusions regarding improved recording devices and techniques are offered.

KINESCOPE RECORDING was initially intended to provide program material to television stations not connected to the major origination centers by either coaxial cable or radio relay facilities. This served to expand the service, to distribute the program expense and to provide advertisers with a larger audience. The rapid growth of interconnection facilities introduces a new problem due to the time difference between the point of program origination and the remote station carrying the same show. The situation can be appreciated by examining Fig. 1 which indicates the problem arising from the time zone difference across the continent. A program originating in New York at 9:00 P.M. would reach the West Coast at 6:00 P.M., much too early for presentation. It appears that the best solution is to record the program on the West Coast at the time of origination and to present a delayed broadcast from this material at 9:00 P.M. Pacific Time. Likewise, a program originating in Los Angeles at 9:00 P.M. would reach the East Coast at midnight, much too late for presentation. One proposed solution is to stage the show at 6:00 P.M. Pacific Time and to transmit it to the East Coast for presentation at 9:00 P.M. Eastern Time, at the same time recording the material for later presentation over the local West Coast Station.

The concentration of experienced talent on the West Coast increases the need for good recordings as does the continuing necessity of providing programs for stations not yet connected by common carrier facilities or unable to transmit the program at the time of origination due to other commitments. While the appeal of television has been sufficient for the public to tolerate a considerable amount of degradation in picture quality, it is obvious that the system must eventually provide enter-

Presented on October 15, 1951, at the Society's Convention at Hollywood, Calif., by P. J. Herbst, R. O. Drew and J. M. Brumbaugh, Engineering Products Dept., RCA Victor Div., Camden 2, N.J.

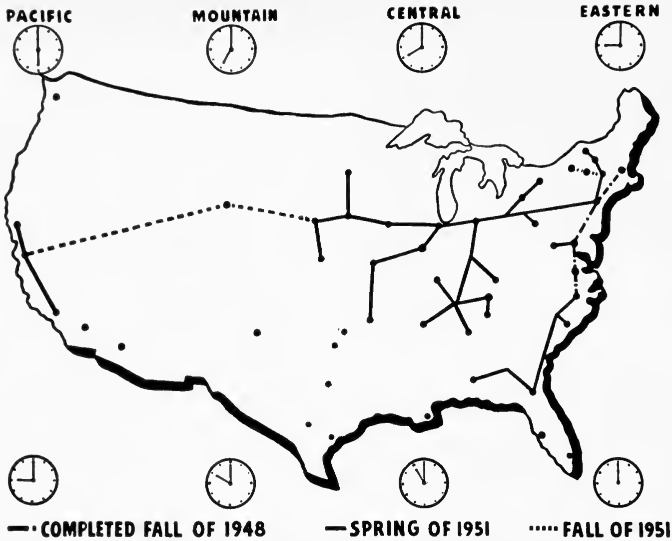


Fig. 1. Basic common carrier facilities for TV.

tainment of a technical quality consistent with that of current studio originations. In view of the importance of this operation to the entire industry, RCA embarked on a broad program of investigation aimed toward uncovering the sources of picture degradation throughout the system and developing the methods whereby the losses and distortions might be minimized. The number of individuals contributing to this effort is too large for separate recognition here as will be appreciated from the fact that personnel at NBC, New York; RCA Engineering Products Dept., Camden; RCA Tube Dept. at both Harrison and Lancaster; the RCA organization in Hollywood; and the RCA Laboratories in Princeton were involved. This paper is intended as a progress report to the industry on the investigations made to date.

Sources of Degradation

While excellent recordings are possible under present conditions, and are being obtained with increasing frequency, such results are not obtained with consistency and the quality of the poorer recordings is so far inferior to studio origination as to cause severe criticism. This picture quality suffers in the loss of detail, the distortion of the gray-scale rendition and in the increase of noise or graininess. In order to obtain the optimum in recordings, the limitations of the system must be understood and the details of operation must be tailored to fit these limitations until the various elements of the system can be improved. The sources of picture degradation are illustrated in Fig. 2.

The first factor affecting quality is the scene lighting. Very contrasty lighting or excessive brightness range is almost certain to introduce spurious shadowing or compression of the gray scale in areas of interest. While the results may not be too bad in the original broadcast, the further distortion introduced by the recording and reproducing processes frequently serve to exaggerate the original defects to a point where the net result is hardly tolerable.

The second factor is the operation of the studio camera. The range in which

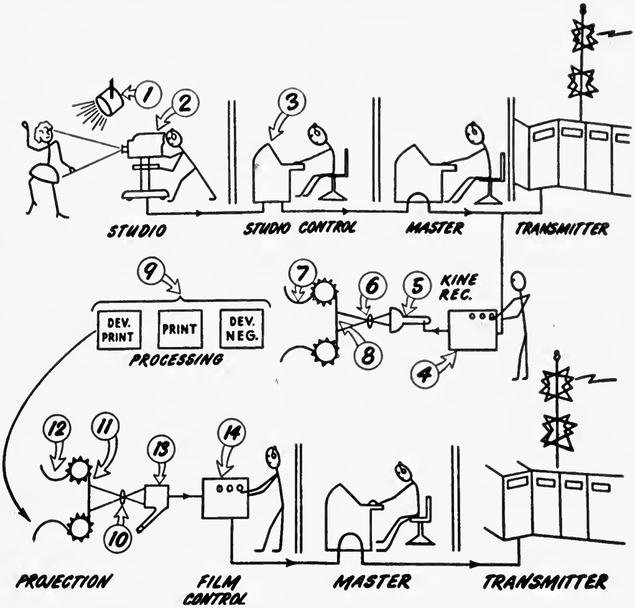


Figure 2.

1. Scene lighting
2. Camera operation
3. Camera control and level setting
4. Recording amplifying circuitry
5. Recording kinescope
6. Recording optical system
7. Camera transport mechanism
8. Film size and emulsion
9. Photographic processing
10. Reproducing optical system
11. Finished recording
12. Projector transport mechanism
13. TV camera pickup tube
14. TV film camera and operation

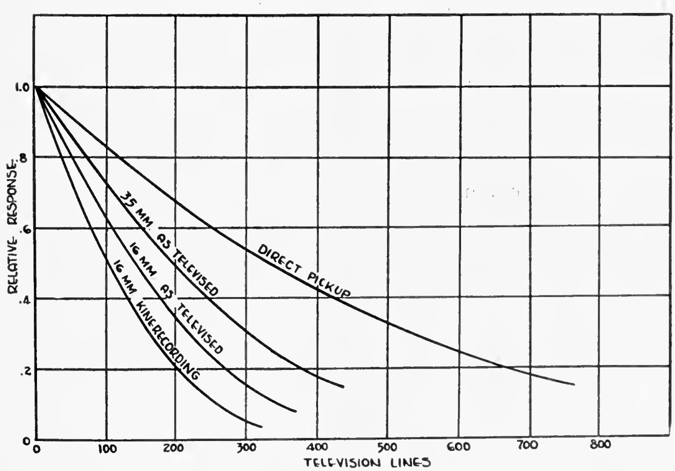


Fig. 3. Effective aperture response, no aperture correction.

an image orthicon will operate without the introduction of excessive distortions due to redistribution effects at the target is not much greater than 30:1; therefore, careful control of the iris of the camera, care in adjusting the operating potentials to insure a reasonable range of operation and precise setting of black levels between cameras are necessary to obtain a picture of optimum quality. Unless the program director, the technical director and the operating personnel all cooperate in this respect, there is nothing that the operator of the recording equipment can do to rectify their mistakes.

The next link in the chain is the amplifying circuitry associated with the recording monitor. In general, this poses no problem since the bandwidth and signal handling range can be made adequate. In fact, it is possible to include some corrective circuits at this point. The adjustment and maintenance of precise levels are more pressing problems than any consideration of losses in the electrical circuits.

The kinescope employed in the monitor represents one of the limiting elements of the system. Considerable effort has been devoted to the improvement of this unit as will be described later. Loss in detail and compression of the contrast range can be introduced at this point.

The optical system of the camera, in fact any lens in the system, can introduce losses in resolution due to poor focus or lens flare. At the present time, these effects are not limiting but improvement in other elements of the system may increase the importance of the losses at such points.

The film transport mechanism in the recording camera can introduce losses by either improper motion of the film or by vibration which causes loss of interlace and smearing of detail.

The film size and the particular emulsion affect both detail and the gray-scale rendition. The film processing also introduces loss of detail and distortion of the contrast depending upon the exposures employed, the development of both negative and print and the precision of the printer.

The television film camera introduces optical and mechanical losses but the most important element in this unit is the pickup tube and its operation. Spot size and dynamic range affect both detail and gray-scale rendition. The latter varies with the particular tube employed and requires either that special compensation be employed or that the characteristics of the recording be adapted to the characteristics of the pickup tube. This is one place where a uniform characteristic is needed, in order that both normal film and kinescope recordings be reproduced with a minimum of distortion. A review of the subject was presented by R. M. Fraser in 1948.[15]

The extent to which fine detail is degraded even under the best current practices may be appreciated by an inspection of Fig. 3. This is a plot of the effective aperture response of a good studio pickup and the reproduction of various types of film material. The subject has been treated in detail by O. H. Schade in previous publications.[1,2,4,6] It is, therefore, sufficient to explain that the plot is in terms of the relative signal amplitude versus television line number.

Several methods of electrically compensating for such losses have been described and circuits are currently in use in many recording studios.[5] Essentially, these circuits are equalizers which accentuate the higher video frequencies representative of the fine picture detail. The precise shape of the response curve and the necessity of including phase compensation to minimize the edge effects due to transients have been discussed in various publications. The effect of such an equalizer

or "aperture compensating" circuit is shown in Figs. 4 and 5. Both are still recordings of the same television signal. Figure 4 shows the results obtained without compensation while Fig. 5 shows the effect when electrical correction is employed. In this case the compensation was excessive as indicated by the pronounced edge effects. However, this was purposely introduced to reduce the need for further correction in the film reproducing equipment. This picture, reproduced over a normal and well-adjusted television film pickup chain, gave very excellent results as regards detail, as shown in Fig. 6. The degree of improvement can be estimated by comparing this result with the reproduction of the uncompensated recording shown in Fig. 7. The extent to which such compensation can be employed is limited by the increase in noise, the accentuation of defects in the original pickup and the introduction of unpleasant edge effects. It is likely to vary with different originations and, at the present time, requires the operator to exercise good judgment in adjusting the compensator for any one scene or program.

The compression of the gray-scale range as the signal progresses through the system is shown in Fig. 8. This subject has also been exhaustively treated by Schade and others.[2,3,4,6,7,8] It will be noted that the linear range of the original studio pickup, when properly adjusted, is in the order of 30 to 1. The same range for normally processed motion picture film when televised without compensation is in the order of 10:1. When the original television studio pickup is photographically recorded and the kinescope recording reproduced over the television system, the linear range is only about 4 to 1. It is, therefore, essential that some means of extending the range of the system be employed. Of course, it is obvious that care must be taken to keep the area of interest in the original pickup within the range of the television system to avoid washed out highlights and muddy shadows.[11,12]

The circuits used for gray-scale compensation are either expanders or compressors. The type varies with the type of tube used in the film reproducing equipment. Circuits providing a response in accordance with a power law of less than unity are used with linear pickup devices such as the flying spot scanner in order to compensate for the high contrast of the final reproducing kinescope. Circuits expanding the highlights are used to overcome the compression introduced by pickup tubes such as the iconoscope and by the recording kinescope as well. Circuits expanding the shadows have been proposed for overcoming the compression of the lower tones by the toe of the sensitometric characteristic of the film stock. The BTL "Rooter" circuits[9] and the NBC "Orthogam" amplifier[10] are examples of such units.

The effect on the reproduced picture may be seen in Figs. 9 and 10. The former is a photograph of a televised image with no electrical compensation while the latter shows the results obtained with the same signal by employing electrical gray-scale compensation. Aperture compensation was not used in either case. Approximately 20% of the original video signal, representing the maximum "white" excursion, was stretched to comprise about 50% of the resulting corrected video signal, with the gradient increasing toward the peak of the "white" signals. Similarly about 10% of the "black" signal was stretched to 20% in the resultant, in order to compensate for the compression introduced by the film characteristic. Since the operation of the studio camera and the film reproducing equipment may both introduce gray-scale distortions which differ widely from the representative curves previously shown, it is difficult to establish an optimum characteristic for the circuit to be em-

Fig. 4. Kinescope recording, no compensation.

Fig. 5. Kinescope recording, excessive electrical aperture compensation.

Fig. 6. Television reproduction on overcompensated recording (shown in Fig. 5).

Fig. 7. Television reproduction of uncompensated recording (shown in Fig. 4).

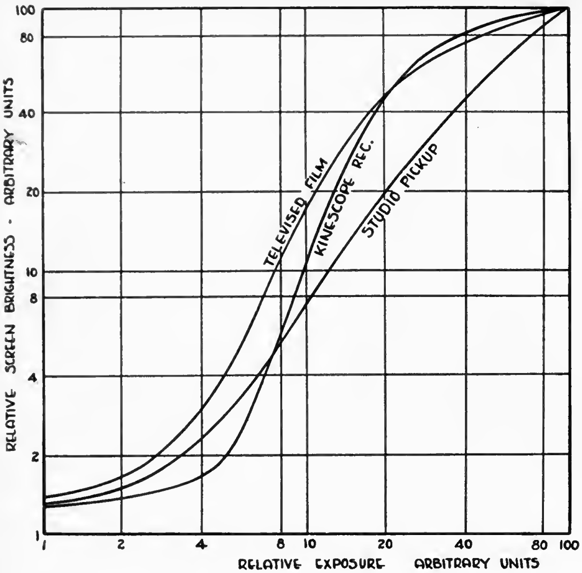


Fig. 8. Contrast rendition transfer characteristics of television system.

ployed at the recording position. It should be appreciated that such compensation may accentuate defects such as flare, shading and halo in a studio origination so that it is imperative for the operator at the camera control position to minimize such effects and for the program director to avoid calling for lighting which makes it necessary to tolerate such defects in order to get a picture at all.

One method of compensation recently proposed does not employ electronic circuits but depends upon photographic techniques. This method depends upon a well-known technique called "area masking" which was described in some detail at the Society's Spring Convention in New York.[8,13,14] It has the advantage of accomplishing both gray-scale compression and effective aperture correction in one process without an appreciable increase in noise. It does, however, have the disadvantage of requiring the preparation of a masking print from the negative and, therefore, requires evaluation as to its operational and economic feasibility. The results obtained can be judged from a comparison of Fig. 9 with Figs. 11 and 12, which show, respectively, the reproduction of a television signal from a normal-contrast subject: firstly, with no compensation and normal film processing; secondly, with no compensation but with a low-contrast print to keep the range of signals within the limits of the television system; and thirdly, with a print of low-contrast range prepared by the area masking process. The correction of the contrast range without destroying the fine detail is easily observed. The principal limitation of the method is in the introduction of edge effects which become objectionable when the compensation is carried to excess.

Kinescopes

The kinescope used in the recorder is far from perfect. In view of the importance of its performance to the overall result, a comprehensive program was aimed at uncovering the manner in which better performance could be achieved. Figure 13 shows the details of the tube which require consideration.

In order to examine the possibilities of realizing better performance, a large number of experimental tubes was constructed and subjected to careful measurements as well as tested in a recording setup. The most important variations tested to date as well as the results obtained are tabulated in Fig. 14. The performance of the experimental tubes is referred to the characteristics of the RCA Type 5WP-11, currently in production. It was suspected that light was dispersed in the phosphor itself thus increasing the size of the scanning spot and decreasing the effective aperture response. Three methods of reducing this effect were investigated. The first consisted in aluminizing the phosphor without the usual collodion backing. This permitted the aluminum to form light barriers between the crystals. As indicated in row B of Fig. 14, tubes made in this manner exhibited excessive grain, poor light output and were hard to drive since the penetration of the scanning beam was seriously reduced by the greater thickness of the aluminum layer. The second approach consisted in reducing the thickness of the phosphor deposited on the faceplate. As indicated in row C of the figure, some improvement in detail contrast was noted in these tubes; however, the major effect was an increase in light output since the thickness of the deposit was more nearly optimum for the potentials at which the tube is designed to operate. The third method consisted in mixing a small amount of light-absorbing material with the phosphor. In the experimental tubes finely divided carbon was used. It was found that the gain in fine-detail contrast was small, that the tubes exhibited serious graininess, and that the light output was appreciably reduced before any appreciable improvement in detail could be observed. The qualitative results are indicated in row D. Attempts were also made to reduce the flare light by decreasing the halation in the faceplate. With gray glass faceplates some improvement in detail contrast was observed and the general flare was decreased but the film exposure was excessively reduced when an effective improvement was obtained. The performance of these tubes is indicated in row E of the figure.

Tubes of greater length and with improved gun structures, row F, were tried in an effort to obtain a finer spot. It was concluded that the size of the electron beam was not limiting but that spreading of the spot in the phosphor and more especially halation in the faceplate were the major causes of loss in detail contrast and resultant loss in resolution. The major improvement obtained by increasing the length of the tubes, row G, was to decrease the deflection angle and thereby provide a more uniform focus. The same result was obtained by redesigning the deflection yoke although this introduced geometric distortion in the form of pincushion. This last effect can be corrected by suitable optical means.[11]

Tubes of larger diameter, row H, were built and tested in the hope that the larger image would permit the realization of improved detail. Since the beam current had to be increased to provide the same exposure of the film stock, it was found that little improvement in this respect was obtained. The effect of the phosphor grain was reduced and the image was more readily observed by the operator and, therefore, easier to monitor. However, the large size required to obtain a worth-while advantage resulted in cumbersome construction and did not appear to be warranted.

Since the screen brightness appears to limit the use of methods of reducing halation and since the P11 phosphor* saturates at a current density which is not sufficient to produce the desired

* The P11 phosphor referred to has a spectral energy characteristic peaking in the blue region, the maximum response occurring at a wavelength of approximately 4600 Angstrom units.

Fig. 9. Kinescope recording, no compensation.

Fig. 10. Kinescope recording, electrical gray-scale compensation.

Fig. 11. Television reproduction of a low-contrast print.

Fig. 12. Television reproduction of an "area masked" print.

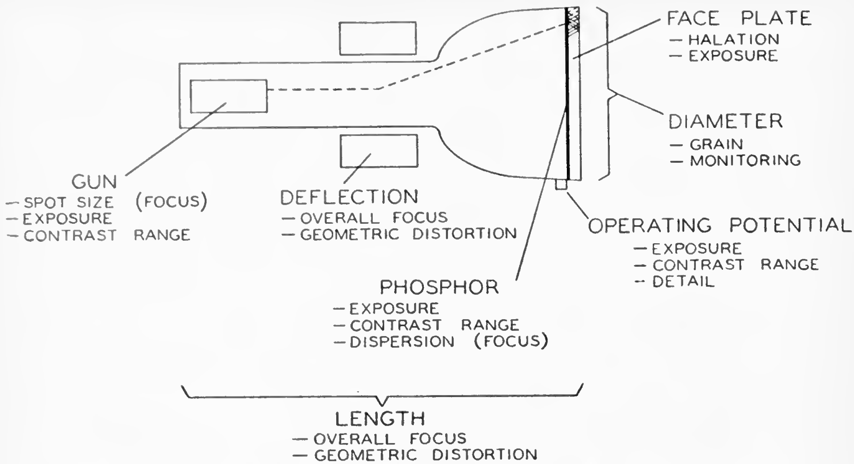


Fig. 13. Features of recording kinescope affecting recorded image.

highlight brightness at the present operating potential, it was decided to construct a tube operating at considerably higher voltage, row I. Experimental tubes similar to those used in theater television equipment but having screens of P11 phosphor were built and tested. The results were highly encouraging. The available exposure of the stock was increased several fold permitting the reconsideration of gray glass faceplates and possible reduction of the aperture in the camera lens. Tubes of this type are now being subjected to tests in order to determine the optimum operating potential, gun design and phosphor thickness.

One method of increasing the effective exposure from the present kinescope consisted of applying a vertical deflection in the order of 20 mc to the scanning beam. This deflection was just sufficient to eliminate the appearance of scanning lines. Measurements indicated a gain in light output in the order of 2 to 1 by the application of this "spot wobble" technique.

Cameras

While high-quality lenses are employed in the camera, they are normally adjusted for optimum correction at infinite focus. In kinescope recording, they are used at relatively short distances and exhibit considerable curvature of the field. The effect can be partially corrected by the employment of a suitable portrait attachment.

One of the most serious defects which can be introduced by the camera is the displacement of the image on the film by vibration. This can completely destroy interlace and cause serious losses in detail. The transmission of energy to the light gun structure of the kinescope is apparently the major source of trouble. Good interlaced recordings have been obtained by isolating the camera and kinescope with proper shock mounts. Care must also be taken to avoid vibrations from other sources affecting the relative position of the kinescope and camera or from causing mechanical displacement of the gun structure in the kinescope.

The film transport mechanism can cause misregistration of the frame and thereby introduce jump into the recorded picture as well as aggravate the effects of shutter bar. The short pull-down cycle imposes severe mechanical problems in the design of this

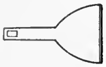
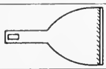
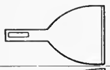
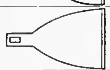
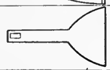
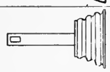
		EXPERIMENTAL KINESCOPE	SPOT SIZE	FOCUS VS. BRIGHTNESS	CORNER RESOLUTION	FLARE LIGHT HAZE	LIGHT OUTPUT AT USEFUL FOCUS	GRAY SCALE RANGE	DETAIL CONTRAST	REMARK
	A	RCA TYPE 5WP11	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	
	B	LESS COLLODION	NORMAL	NORMAL	NORMAL	SLIGHT IMPROVEMENT	LOW	ABOUT NORMAL	SOME IMPROVEMENT	EXCESSIVE GRAIN EXCESSIVE DRIVE REQUIRED
	C	THIN SCREEN	NORMAL	NORMAL	NORMAL	SLIGHT IMPROVEMENT	APPROX. 2:1	SOME IMPROVEMENT	SOME IMPROVEMENT	
	D	CARBON IN PHOSPHOR	NORMAL	NORMAL	NORMAL	SOME IMPROVEMENT	LOW	ABOUT NORMAL	SOME IMPROVEMENT	EXCESSIVE GRAIN
	E	GRAY GLASS FACE PLATE	NORMAL	NORMAL	NORMAL	SOME IMPROVEMENT	LOW	ABOUT NORMAL	RELATIVELY WORSE	
	F	IMPROVED GUN	NORMAL	NORMAL	SOME IMPROVEMENT	NORMAL	NORMAL	NORMAL	NORMAL	
	G	DECREASED DEFLECTION ANGLE	NORMAL	NORMAL	SOME IMPROVEMENT	NORMAL	NORMAL	NORMAL	NORMAL	
	H	LARGE TUBE	NORMAL	NORMAL	NORMAL	NORMAL FOR FINE DETAIL	ABOUT NORMAL	ABOUT NORMAL		BETTER MONITORING
	I	50 KV.	UNDER INVESTIGATION							

Fig. 14. Tube variations tested, with results of tests.

mechanism and sometimes the motion of the film was not completely stopped before the shutter opened. This resulted in smearing of the television lines over this region of the image. These defects have been entirely eliminated in experimental equipment by the use of a modulated pressure pad and the redesign of the registration pins.

The methods currently employed to photograph the 60-field/sec image of the television system on the 24-frame film used in motion pictures all require that the television image be "spliced" at some point within the picture area.[18] When mechanical shutters are employed, an interval of several lines is required to complete the operation of opening and closing. During this interval, the rate at which the illumination increases and decreases must be carefully balanced so that a uniform exposure is obtained. When properly adjusted, the splice is invisible. When this balance is not obtained, the difference in exposure causes a fluttering or local flicker to appear in the vicinity of the "splice."

Instead of a mechanical shutter, it is possible to blank out the picture on the face of the kinescope by electronic means. Such an electronic shutter was successfully demonstrated several years ago. Recently, the technique was reinvestigated to determine the practical advantages and limitations which it offered. The realization of adequate precision in the timing devices necessary to produce the special blanking signal was not difficult to achieve. However, the stability and regulation required of all associated circuits appeared to be excessive since exact interlace must be obtained at all times. Small displacements of the raster not observable with a mechanical shutter appear as white or black horizontal streaks in the picture.

Moreover, the interruption of an image of this brightness for a relatively long period and at a 24-frame rate produces a flicker which makes it difficult to observe the image for any extended period of time and prevents continuous monitoring by the operator. In either case, precise adjustment and the application of proper mechanical or electrical shading to balance the exposure resulted in the elimination of such defects. The matter is more one of maintenance than of optimum performance.

Photographic Processes

The choice of currently available film stock suitable for kinescope recording is limited. High-speed negative emulsions are generally too grainy, especially for 16mm recordings, while fine-grain emulsions are usually confined to relatively slow-speed materials. With these, it is difficult to obtain a sufficient range of exposure due to the relatively low brightness of the kinescope. Care must, therefore, be exercised in the setting of the black level in order to avoid compression in the shadows since the stock is usually worked at lower than average densities while at the same time the highlights must be adjusted to realize the maximum exposure without phosphor saturation or spot defocusing. On Eastman Kodak Co. Type No. 7273 film stock, comparatively good results can be obtained by exposing to obtain densities of 0.2 and 1.2, respectively, with development to a control gamma of approximately unity. In general, current practices appear to be employing the available emulsions to the limit of their possibilities and little advantage seems likely to accrue from variations in processing parameters unless the exposure can be appreciably increased.

Because the available highlight brightness in the kinescope image at current densities less than saturation does not provide normal exposure of the recording stock, the operators frequently tend to overdrive the kinescope in order to obtain an apparent good contrast range on the negative. This tends to exaggerate any compression in the original signal and is probably the principal reason for the criticism leveled at the recording technique.

There are several different approaches to the recording, distribution and reproduction of kinescope recordings. The first and most direct approach employs a positive image on the face of the kinescope and produces a negative image on the recording stock. This negative may be televised, thus eliminating the losses involved in the printing process, or positive prints may be made from it for release to other stations. The former process may be used for local delay broadcasts or for cases where the time required to transport the original negative to the remote station can be tolerated and where only one such transmission is involved.

The second approach is to employ a positive image on the kinescope but to photograph this image on reversal stock. Good results have been obtained in this manner but the lack of positive prints for distribution makes its application limited as in the case of employing a direct negative for reproduction.

The third approach employs a negative image on the face of the kinescope, and provides a direct positive for reproduction over the television system. The film thus obtained is likely to be of low contrast and may not appear satisfactory for direct projection. However, good results have been obtained over the television system. The method is open to the objection that no release prints are available.

The fourth method is to photograph a negative image on the kinescope on reversal stock. The reversal negative thus obtained can then be used to produce release positive prints. Very poor results have been obtained with this technique.

Since prints for release should be positives to permit the insertion of local trailers and since such releases are necessary for all conditions except for network originations, it appears that the conventional method of photographing a positive kinescope image on normal stock offers the best practical solution.

The losses introduced by the printing process have also been investigated. Carefully measured negatives have been distributed to processing laboratories with requests for processing under usual conditions so that data relating to the differences between various printing methods might be obtained. Unfortunately, it has been difficult to obtain the full cooperation of sufficient laboratories to permit definite conclusions to be drawn. The effort is continuing and it is hoped that eventually it will be possible to recommend improvements in both printers and printing techniques.

For some time, the use of 35mm film has been suggested as a means of realizing greater detail in recordings. While this may prove to be practical for network usage where stations are equipped with 35mm television film projectors, it will be necessary to distribute release prints on 16mm film since many local stations operate with 16mm projectors and do not have 35mm facilities. Furthermore, even though most release prints are on acetate stock, local fire ordinances require special precautions when 35mm film is used to insure protection against the possible employment of nitrate film. It seems unlikely that such restrictions will be removed in the near future. It will, therefore, be necessary to accept the limitations on detail which the smaller film size imposes. While the difference in detail is significant, acceptable results can be obtained on 16mm film by minimizing the losses in the remainder of the system and by employing optimum electrical aperture correction. Fortunately, the emulsions are identical so that no further loss in gray-scale rendition is introduced.

Monitoring

It will be appreciated that the narrow range of the television system and the need to employ this range to the best advantage in exposing the film will require considerable precision in establishing brightness levels on the face of the kinescope. Visual observation is not sufficiently accurate for this purpose and monitoring the video signal applied to the recording kinescope does not measure actual brightness and is limited in the precision with which the observation of levels can be made on the associated oscilloscope displaying the video waveform. In order to provide a more reliable means of establishing the recording levels, a generator was developed which furnished a video signal in the form of a series of steps. This generator is, therefore, the electrical equivalent of a photographic density wedge. The overall amplitude of this signal is adjusted to fit the video range of the signal provided from a master control. The picture produced on the face of the kinescope is, therefore, a group of bars of varying brightness each of which represents a distinct video voltage level. The pattern on the face of the kinescope is picked up by a calibrated photocell and the output is displayed on an oscilloscope. The bars are arranged horizontally in order to minimize the effects of phosphor decay which would tend to average the brightness along a horizontal line if vertically disposed bars were employed.

Film Reproduction

In order to complete the review of the entire system, it is necessary to include the performance of the pickup tubes available for television film reproduction and the characteristics of the projectors associated with them.

The pickup tubes of current interest include the iconoscope, the image

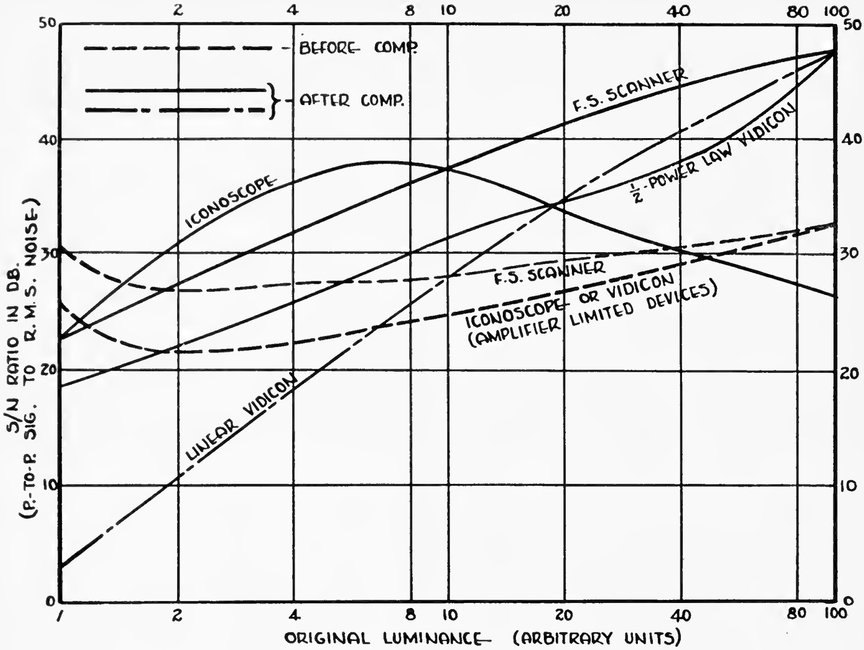


Fig. 15. Effect of gamma compensation on signal-to-noise ratio.

orthicon, the flying spot scanner and the vidicon. The gray-scale characteristics of these devices differ in several ways and affect the type of compensation that is inserted in the system. This aspect has been discussed previously at some length in several publications.[16,17] The noise characteristics of the several tubes differ so that the degree to which compensation may be employed to advantage also varies. The relative performance of several tubes as regards noise in the reproduced image may be estimated from the representative characteristics plotted in Fig. 15. It will be noted that a linear device such as a vidicon is seriously limited if the noise originates in the first amplifying stage. This limitation will be alleviated if the device can be made to have a power-law response of less than unity. Image orthicons of the presently available types have been employed as film pickup devices and are currently in use to some extent. Under present conditions the relatively narrow range over which these tubes can be operated without gray-scale distortion, the susceptibility to burning-in of fixed images and the rather critical adjustments required for satisfactory operation present problems which must be considered in evaluating their application to present-day operations. Therefore, although future developments may remove these difficulties, interest is currently directed toward the iconoscope and the flying spot scanner for this application.

The iconoscope is a storage device and as such, permits the use of projectors of conventional type since the storage permits the use of long pull-down cycles. However, best results are not obtained under such conditions and the use of long application times with short pull-down cycles has been shown capable of reducing such undesirable characteristics as shading and edge flare.

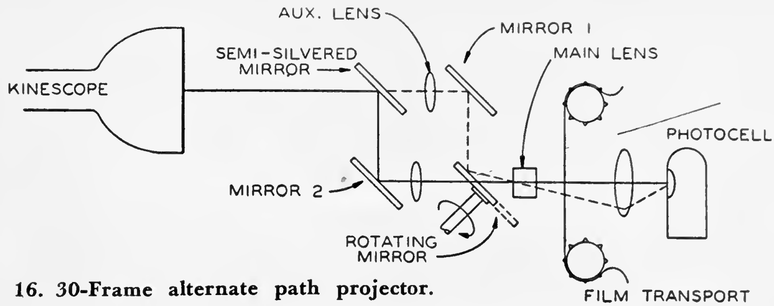


Fig. 16. 30-Frame alternate path projector.

Moreover, the performance can be further improved by the application of proper edge lighting and back lighting as well as circuitry to provide an essentially constant background signal level under wide changes in scene brightness.

The flying spot scanner does not make use of the storage principle and, therefore, requires the scanning spot to be maintained in proper register with the film at all times. The two types of projectors which have been suggested to accomplish this are either the fast pull-down projector, in which the film is pulled down in the television blanking interval, or the continuous projector, in which the film moves at a constant rate and proper registration is maintained by either optical or electrical displacement of the image of the scanning spot.

Several experimental models of fast pull-down projectors have been built. These devices have all been designed for 16mm film. Obviously the problems associated with minimizing the wear on both film and mechanical parts due to the high accelerations involved will require extensive life tests before the practicability of any design of a film transport mechanism can be evaluated. The ability of the mechanism to provide accurate registration in such a short pull-down time also presents mechanical problems. The results obtained on one model have been highly encouraging. After more than 400 passes through this model, no damage to the film sprocket holes was observed. Moreover, no perceptible increase in jump was observable with the SMPTE test film after more than 50 hours of operation. While these results must be confirmed by further operation over an extended period of time, it would seem that flying spot scanner operation with this type of projector is within the realm of possibility.

Continuous projectors are of two fundamental types: (1) those that allow the film motion to accomplish a portion of the vertical scanning and employ optical or electrical means to deflect the scanning raster to the proper position at the beginning of each scan; and (2) those that use continuously varying optical means to maintain registration of the raster and the film as the film moves.

The first type has been used in Europe where the 50-field television standard permits a relatively simple alternate positioning of the raster by running the film at a rate of 25 frames. For U.S. television standards, this would require a special 30-frame film. One version of such a projector is illustrated in Fig. 16. Since there are only two television fields for each film frame, only two positions of the scanning raster are required. The system shown employs mirrors to deflect the beam and provide the two alternate paths. Since the mirrors can be relatively large, a projection lens of high speed can be used. A projector of this type was built and tested and found to operate extremely well. Care must be taken to maintain

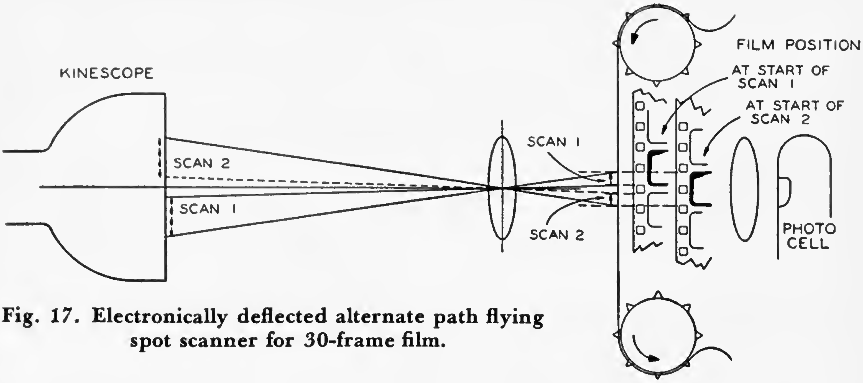


Fig. 17. Electronically deflected alternate path flying spot scanner for 30-frame film.

equal transmission over both of the paths to avoid flicker at a 30-cycle rate.

When 24-frame film is to be televised at a 60-field rate, it is necessary to scan one film frame with two television fields and the next with three. In a projector of either of the foregoing types, five alternate paths must be provided. In the multiple-lens case, this means a still further reduction of lens speed. In the second system, cams may be employed to position the unused mirror while the other is in use and held stationary. An experimental model of such a unit has been built but tests are not sufficiently advanced to permit an evaluation of its merits at this time.

Instead of shifting the effective position of the raster by interposing optical elements between the kinescope and the objective lens, it is possible to accomplish the same result by displacing the raster vertically on the face of the kinescope. The principle, as applied to 30-frame film, is illustrated in Fig. 17. It will be appreciated that extreme linearity of scanning and a minimum of geometric distortion must be achieved in order that the registration of successive fields be obtained. The system has also been tried for 24-frame film and U.S. Television Standards. The problem of registration is of the same order of magnitude as before but an additional problem of unequal duty cycle of various areas on the face of the kinescope is introduced due to the unavoidable overlapping between the displaced rasters. As the tube ages, objectionable flicker may be introduced should this produce unequal light output from the several areas.

Projectors in which moving optical systems have been employed to maintain constant registration with a moving film have been attempted for some time. These have employed rotating lens disks and drums, rotating prisms and rotating mirror systems. The first two systems require extreme precision in the optical elements, are inherently low in light efficiency and are difficult to compensate over the desired range of travel. The last system was originally developed by Meccau in Germany and produced satisfactory results although it was difficult to maintain proper adjustment. Recently this principle has been revived and appears to offer considerable promise of satisfactory and practical operation.

The promised improvements in film pickup equipment will considerably improve the results obtained from kinescope recordings as well as from normal film material by eliminating many of the defects present under current conditions, and by providing more stable and uniform characteristics, thereby reducing the variability injected by the continual adjustment in accordance with the operator's judgment.

Summary of Current Status

The present status of kinescope recording may be summarized as follows:

1. Good quality is possible with present equipment by careful control of the lighting and staging and by proper operation of both the studio camera and the film reproducing equipment. This imposes objectionable restrictions on programming but must be tolerated until further improvements can be realized.

2. Some improvement can be obtained by the use of electrical correcting circuits but care must be taken to avoid overemphasizing the defects in the original pickup.

3. Some improvement in kinescopes has been obtained. Current limitations are expected to be removed to some extent by the use of higher operating potentials.

4. Satisfactory camera mechanisms can be realized and either the mechanical or electronic shutters can be adjusted to eliminate visible shutter bar. The latter, however, introduces problems in maintenance and monitoring.

5. Better monitoring techniques can be employed. The use of a step function generator and a photocell monitor promises to provide greater uniformity and more precise exposure.

6. Present photographic processes appear to be capable of very little improvement under present conditions. An increase in kinescope brightness or the introduction of a new emulsion might make changes in processing desirable.

7. The photographic compensating technique known as "area masking" offers advantages but requires evaluation from the operational and economic standpoints.

8. Improved film pickup equipment offers the possibility of minimizing the losses introduced during reproduction.

Conclusion

It must be emphasized that the losses and distortions in the system are the summation of a number of individual deficiencies and that an improvement in one element may be masked by degradation contributed by the remainder of the process. No one element is responsible for the overall loss of detail or distortion of contrast so that many small improvements must be attained before an outstanding improvement is made in average reproductions. Until such time as these improvements can be included in the system, program directors and technical directors would be well advised to maintain a careful control over lighting, staging and camera operation if they expect acceptable quality to be realized in the recorded program.

References

1. O. H. Schade, "Electro-optical characteristics of television systems: Part I, Characteristics of vision and visual systems," *RCA Rev., 9:* 13–37, Mar. 1948.
2. "Part II, Electro-optical specifications for television systems," *ibid.*, 245–286, June 1948.
3. "Part III, Electro-optical characteristics of camera systems," *ibid.*, 490–530, Sept. 1948.
4. "Part IV, Correlation and evaluation of electro-optical characteristics of imaging systems," *ibid.*, 653–686, Dec. 1948.
5. E. D. Goodale and R. C. Kennedy, "Phase and amplitude equalizers for television use," *RCA Rev., 10:* 35–42, Mar. 1949.
6. O. H. Schade, "Image gradation, graininess and sharpness in television and motion picture systems: Part I, "Image structure and transfer characteristics," *Jour. SMPTE, 56:* 137–177, Feb. 1951.
7. F. G. Albin, "Sensitometric aspect of television monitor-tube photography," *Jour. SMPE, 51:* 595–612, Dec. 1948.
8. P. J. Herbst, R. O. Drew, and S. W. Johnson, "Electrical and photographic compensation in television film reproduction," *Jour. SMPTE, 57:* 289–307, Oct. 1951.
9. B. M. Oliver, "A rooter for video signals," *Proc. IRE, 38:* 1301–1305, Nov. 1950.

10. E. D. Goodale and C. L. Townsend, "The orthogam amplifier," *RCA Rev.*, *11:* 399–410, Sept. 1950 (abstract, *Jour. SMPTE, 56:* 76–78, Jan. 1951).
11. W. T. Wintringham, "Tone rendition in photography," *Proc. IRE, 38:* 1284–1287, Nov. 1950.
12. B. M. Oliver, "Tone rendition in television," *Proc. IRE, 38:* 1288–1300, Nov. 1950.
13. M. V. Johnson, "Print control with blurred positive masks," *Am. Phot.*, *37:* 14–16, Mar. 1943.
14. J. A. C. Yule, "Unsharp masks," *J. Phot. Soc. Am.*, *11:* 123–132, Mar. 1945.
15. R. M. Fraser, "Motion picture photography of television signals," *RCA Rev.*, *9:* 202–217, June 1948.
16. R. B. Janes, R. E. Johnson and R. S. Moore, "Development and performance of television camera tubes," *RCA Rev.*, *10:* 191–223, June 1949.
17. R. L. Garman and R. W. Lee, "Image tubes and techniques in television film camera chains," *Jour. SMPTE, 56:* 52–64, Jan. 1951.
18. F. N. Gillette, "The picture splice as a problem of video recording," *Jour. SMPTE, 53:* 242–255, Sept. 1949.

Discussion

Anon: Where on the response curve does the corrected mask fit on the chart that was shown for the response for the live studio 35mm film and the kinescope film?

P. J. Herbst: I don't get the question. Where, on which response curve is what?

Anon: There was one of the charts shown on the screen, one that showed the response for a live pickup for 35mm and for 16mm, and I just wondered where the masked area...

Mr. Herbst: Oh, you mean area masking, how much that improved it?

Anon: That's right.

Mr. Herbst: I'm sorry I hadn't understood. I would say this. I think that just from observation it brings it up to something; it'll bring a 16mm recording up to something that is not quite as good as the 35mm reproduction over the TV system.

Anon: In the interests of settling the question, which is the more authoritative source of technical information, the gossip columns or the proceedings of this learned Society? I would like to have you express something about the future of photographic kinescope recording vs. magnetic recording of the image.

Mr. Herbst: A magnetic recording would be fine if we knew how to do it.

Anon: You probably haven't been reading the Hollywood columns in the last couple of weeks, but it's supposed to be a reality.

Mr. Herbst: I haven't seen any of it yet. I'm sorry.

Anon: I wonder if we can still stay in business.

Mr. Herbst: I think, to answer your question, that unless someone has come out with magnetic heads and magnetic materials which are capable of much higher frequencies than we've gotten so far (and that may be possible), until that happens, I don't think that photographic kinescope recording will be abandoned.

F. N. Gillette: Regarding the question that was raised just a moment ago, is it really proper to consider this area-masking technique as a means of improving the response curve of the system? It's more a means of improving the tone values, isn't it?

Mr. Herbst: Yes, but it also improves the large-area tone values—in other words, it reduces them to a value which the system can handle. At the same time, it leaves the fine-detail contrast where it was. So, essentially it's exactly the same thing as increasing the gain at the higher frequencies. I think that Otto Schade's old paper some years ago pointed out that you could do that. It doesn't make any difference whether you do it electrically or photographically.

Dr. Gillette: But actually does it amount to an increase in fine-detail contrast in any region which was properly treated by the techniques previously used?

Mr. Herbst: Oh, yes, it is increased in every region. Look at it this way. The mask is merely a way of reducing in any given area the exposure which is given to the print. If you did the same thing by dodging in an enlargement you wouldn't reduce the detail contrast any. You would merely reduce the overall contrast between large areas. The result is an increase in detail contrast relative to large-area contrast in all ranges of the picture, not just in the highlights and in the shadows.

Anon: You mentioned earlier some improvements on iconoscope film chains. Is information on these improvements available?

Mr. Herbst: Well, we expect to have that out shortly.

Multichannel Magnetic Film Recording and Reproducing Unit

By C. C. DAVIS, J. G. FRAYNE and E. W. TEMPLIN

The multichannel magnetic film recorder and reproducer provides three 200-mil tracks in accordance with proposed ASA standard for 35mm film. The effective crosstalk between adjacent tracks approximates −60 db and flutter content does not exceed 0.05%. Complete recording and reproducing transmission equipment is housed in the recorder and associated base cabinet. The recording channels operate from a nominal input level of −30 dbm, and a reproduced output of +16 dbm is obtained from each of the reproducing channels. Monitoring of each channel is provided from a separate triple-track head.

THE COMBINATION magnetic recorder-reproducer described in this paper was developed to meet the needs of the motion picture industry for a high-quality triple-track magnetic recorder. The use of a triple-track recorder was anticipated by the industry in formulating the magnetic-track standards for 35mm sprocket-hole film, provision being made that one of the three tracks recorded in such a machine should correspond in position with that of a single track recorded in an ordinary magnetic-film recorder. In fact, the performance specifications for the triple-track machine, especially those which specified the crosstalk between adjacent tracks, proved to be a determining factor in the location of the single track in the regular motion picture production magnetic recorder. The final triple-track standards as adopted by the Society's Sound Committee and which are now being considered for standardization by ASA are shown in Fig. 1. Reference to this figure will show that three 200-mil tracks are provided with a separation of 150 mils between tracks, the edges of the outside tracks being 50 mils from the sprocket holes. The proposed standard calls for a crosstalk figure between adjacent tracks of at least −50 db.

At the time of the formulation of the track standards, it was thought that the −50 db value of crosstalk would be satisfactory for the then intended uses of the triple-track recorder. However, as the industry began to use this new medium, the demand for a greater reduction of crosstalk became imme-

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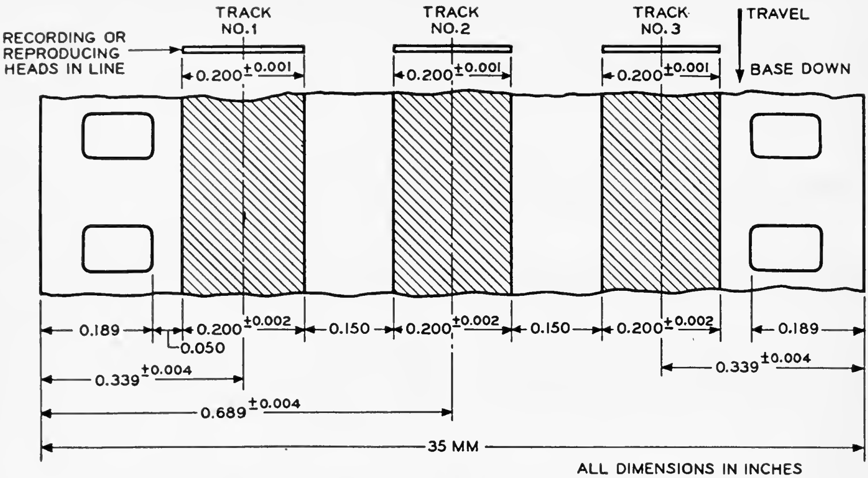


Fig. 1. Triple-track magnetic specifications.

diately evident and, as will be described later in this paper, means have been found for obtaining a crosstalk figure of approximately −60 db at 1000 cycles on a regular production basis. Exhaustive listening tests have shown that with this amount of crosstalk at 1000 cycles, no audible sound is heard in any track from a fully modulated signal in an adjacent track, whereas with the original value of −50 db, audible crosstalk is very much in evidence. If completely unrelated sound recordings are to be made on the three individual tracks, it seems highly necessary that a successful triple-track magnetic recorder meet the −60-db cancellation figure.

The intended uses for this type of magnetic recorder include the multichannel scoring operation in which this single machine would replace three existing single-channel recorders with the attendant economy in film usage and in manpower, as well as provide a much greater convenience in operation. A second major use of the triple-track recorder is that of providing storage of three individual tracks on a single film, thus providing a marked saving in vault space. These three tracks could be entirely unrelated or they could be used, for example, for storing dialogue, music and effects tracks on a single film. Other uses, of course, will be found particularly in the re-recording operations as the studios get more familiar with the possibilities of this type of recorder.

In order to facilitate the early introduction of this new recorder to the industry, it was decided to utilize the basic mechanism of the RA-1251 Re-recorder[1] which has had such wide acceptance in the industry for both photographic and magnetic re-recording. In order to accommodate a triple-track head providing three recording heads in line and locating them in a low-flutter film path, a double flywheel drive was substituted for the customary single unit. Two complete triple-track heads, one used primarily for recording and the second for monitoring or playback, are mounted in the film path between the two impedance drums mounted on the separate flywheel shafts. The arrangement of the film path and location of the two triple-track heads are shown in Fig. 2. It will be noted that the elements of the Davis Drive, pre-

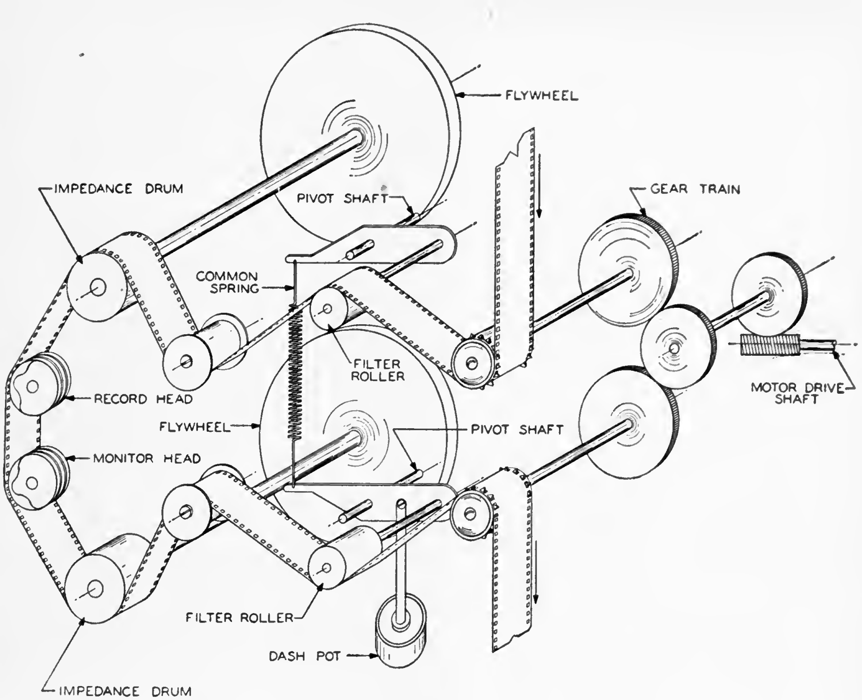


Fig. 2. Triple-track recorder film path schematic.

viously employed in the RA-1251, are retained. The single flywheel is removed, a new subassembly is substituted which carries the two individual flywheels, the mounting for the triple-track heads and a Permalloy shield box to isolate the heads as far as possible from magnetic pickup of extraneous fields. The combined moment of inertia of the two flywheels approximates that of the single flywheel, so that the natural period of the filtered film path remains essentially the same. The performance of this drive from a flutter standpoint is quite comparable to that of the RA-1251 Re-recorder when set up originally for photographic purposes. The total rms flutter for an average machine amounts to approximately 0.05% based on flutter frequency rates ranging from 2 to 200 cycles, the flutter at any given rate not exceeding 0.03% rms.

Figure 3 shows an electrical analogue of the film-drive filter mechanism, the components being designated below the illustration.

The basic elements of this circuit were previously shown to illustrate the double-arm or tight-loop filter mechanism for a photographic film recorder.[2] At that time an explanation was offered for the action of the common spring, C_1 and the double-sprocket drive, S_1 and S_2, including the general characteristics and attenuation curves of flutter disturbance originating in either or both of the sprockets.

The present circuit shows the addition of six elements which represent the additional flywheel and the significant items associated with the film passage over the magnetic heads. While six elements have been added, the film-filter performance remains substantially

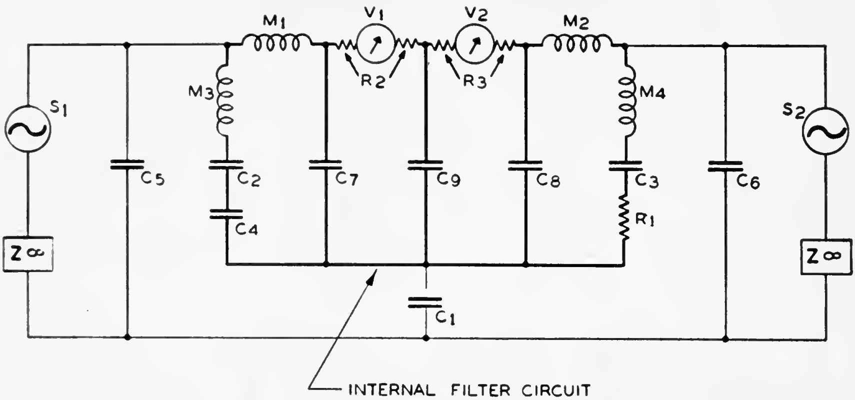


Fig. 3. Film-drive electrical analogue.

M_1 & M_2, Inertia of flywheels
M_3 & M_4, Inertia of upper & lower filter arms
C_1, Compliance of spring common to both arms
C_2 & C_3, Compliance of arms when moving together
C_4, Compliance of arm-positioning spring
C_5 & C_6, Compliance of film between flywheels & sprockets
C_7 & C_8, Compliance of film between flywheels & heads
C_9, Compliance of film between heads
S_1 & S_2, Upper & lower film drive sprockets
R_1, Resistance of dashpot damper
R_2 & R_3, Resistance of film over heads
V_1 & V_2, Reference film velocity at heads

unchanged from a single-flywheel type. This is because the elements C_7, C_8 & C_9 and R_2 & R_3 represent relatively small magnitudes, and M_1 & M_2 tend to become a single flywheel as these elements decrease in value. C_7, C_8 & C_9 are short, stiff lengths of film and, therefore, constitute small values of compliance. Likewise, R_2 & R_3, representing the effective damping resistance of the film friction over the heads, have relatively small values. This results from the well-known characteristic of solid or sliding friction acting at considerable velocity, as compared to viscous friction, because of their differences in force-velocity characteristics.[3] This may be illustrated by removing the dashpot, R_1, whereby the small remaining amount of damping caused by film friction permits highly undamped oscillation of the filter arms following a disturbance.

The displacing force created by film friction over the magnetic heads is offset by an adjustable spring, C_4. By this means the filter arms can be maintained in their correct operating positions in spite of large differences in the frictional coefficient of various film samples.

In the present design, forward-running speed of 90 ft/min is provided and the customary high-speed rewind is retained. For special applications where reverse operation at standard speed is required, a double torque-motor drive will be furnished for each film-spool spindle. A footage counter located in the central angle bracket is an added feature of the triple-track recorder.

The associated transmission equipment providing for three complete recording channels and three complete reproducing channels, operating at a nominal recording input level of −30 dbm and reproducing an output level

of +16 dbm, is housed in both the upper section of the recorder cabinet and in the associated base cabinet, as will be observed from Fig. 4. This provides for a maximum economy in recording-room space as well as in all the facilities and controls needed for operation of a triple-track machine. Complete details of the recording and reproducing transmission circuits and controls are described later in the paper.

Triple-Track Magnetic Head

The triple-track RA-1508 Magnetic Head shown in Fig. 5 is based on construction principles used in single-track heads previously described.[4] Basically, it is a ring type with two stacks of Permalloy laminations cemented in the divided halves of a hollow ring. This machined brass ring provides accurate reference surfaces for the otherwise irregular dimensions of the pile-up of laminations. These serve as a foundation for the manufacture of identical units which are combined into multi-track heads exhibiting close tolerances relative to track placement and azimuth alignment as a group. Thus, no individual adjustment is required for azimuth or track adjustment. The groups comprising the recording and reproducing heads are placed on a mounting bracket which provides facilities for adjusting the record and reproduce heads as units. The film is aligned with the entire assembly by an adjustable guide-roller as in the original photographic machine.

Interference or crosstalk in multi-track magnetic recorders, wherein the tracks are recorded simultaneously in line across the magnetic medium, results mainly from the fact that several heads lie side by side, separated by incomplete shielding since a considerable portion of the heads must be exposed to contact the recording medium. This type of crosstalk may be referred to as electrical because it evidences itself without the presence of any recording medium. It is the source of troublesome crosstalk

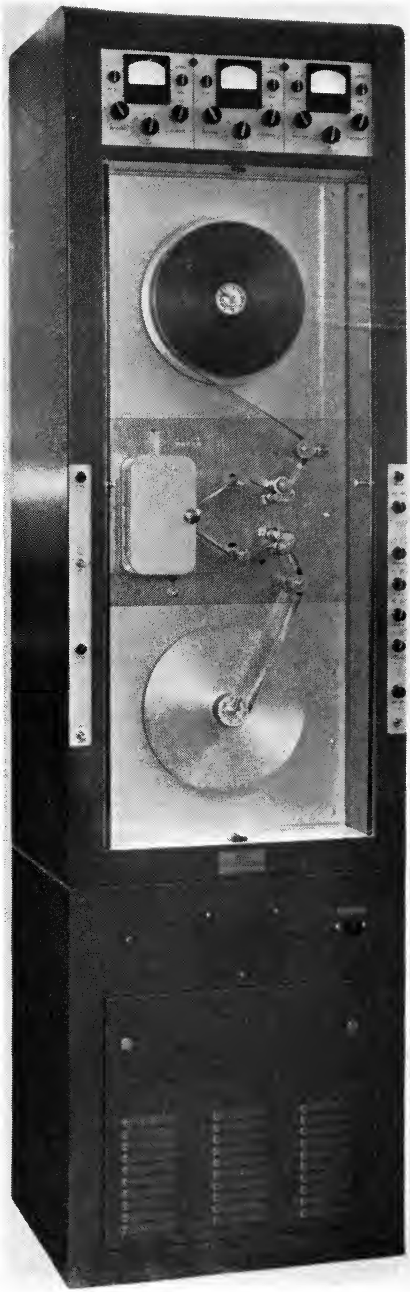


Fig. 4. Front view of RA-1506-A triple-track recorder.

in program material. A close phase relationship may be shown to exist between the original recorded track and the track produced by the induced flux in the adjacent head. Another form of crosstalk exists only at low frequencies or long wavelengths and normally is not a source of trouble in program material because of ear characteristics and the energy distribution of speech and music. It occurs when the recorded wavelength becomes comparable to the distance between tracks and the fringing flux becomes well defined and of such intensity in the adjacent track area as to constitute interfering crosstalk.

Special means have been incorporated in the recording- and reproducing-head assemblies to reduce crosstalk among the three heads. These consist of small magnetic paths introduced diagonally between one-half of each magnetic head and the corresponding opposite half of the adjacent head, and of such proportions and phase relationship as to cancel effectively the crosstalk leakage from one head to the other. These substantially decouple the two heads electrically or magnetically and are referred to as decouplers. In the case of a triple-track head only two decouplers are required since their action is, for all practical purposes, reversible. They handle relatively small amounts of flux and do not alter the normal characteristics of the recording and reproducing heads or the overall system in any way.

Without the application of decouplers, heads similar to those described evidence crosstalk interference of about −45 db. This refers to the ratio of crosstalk induced from a fully modulated signal in an adjacent track relative to a fully modulated signal in the track in question. While experiment has shown that crosstalk values better than −50 db may be obtained by increased shielding, particularly of such form as to compartment the tracks on both sides of the film, this method presents threading difficulties and, as previously stated, values considerably better than −50 db are necessary for general professional use. Therefore, the decoupler method has been developed and values of at least −60 db are obtained at 1000 cycles.

While a value of approximately −60 db of crosstalk at 1000 cycles has been obtained in this design, it will be noted from reference to Curve 1 of Fig. 6 that although the crosstalk stays appreciably constant from 150 to 3000 cycles, it rises to a value of about −45 db at 50 cycles and −48 db at 10,000 cycles. The increase at the low frequencies has been discussed above. The increase at the high frequencies simply reflects the closer coupling between adjacent heads at the high-frequency end of the spectrum. In Curve 2 of Fig. 6, the 40-db ear-weighting characteristic has been added to the experimental data used in Curve 1 and it is obvious that with this correction the effective crosstalk at low frequencies is well below audibility. Many listening tests with a wide variety of recorded material confirmed the selection of 1000 cycles as a suitable frequency for adjustment of the decouplers and for the attainment of −60 db at this frequency as a guarantee against any audible crosstalk in the recording audio spectrum.

The decouplers consist of several small strips of Permalloy extending diagonally from a point near the recording gap of one head to a similar point on the adjacent head. A small air gap at either end is adjusted for optimum operating conditions with the help of a wave-analyzer, after which the decouplers are locked in place.

The individual heads are separated by a double thickness of magnetic shielding material to reduce hum pickup from external sources. The complete head assembly is enclosed in a box of heavy magnetic material, the front half being hinged to allow access for threading.

Fig. 5. RA-1508-A triple magnetic head.

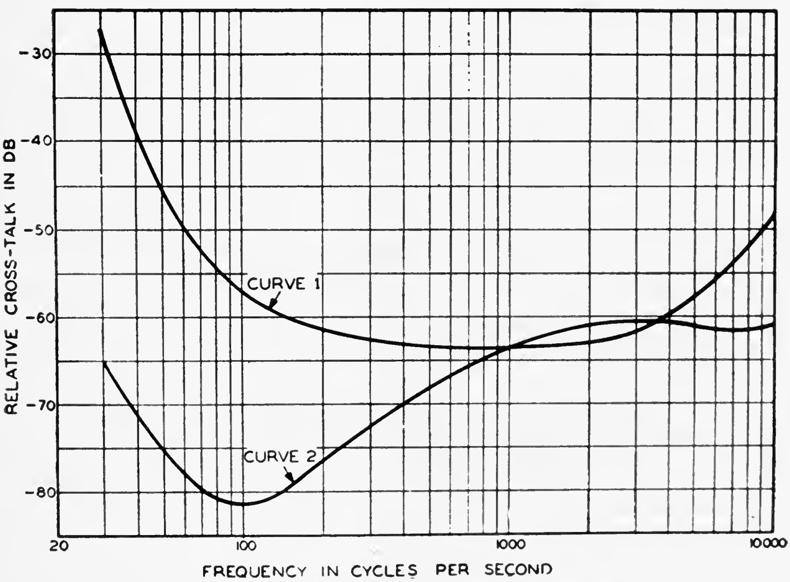


Fig. 6. Crosstalk as a function of frequency.

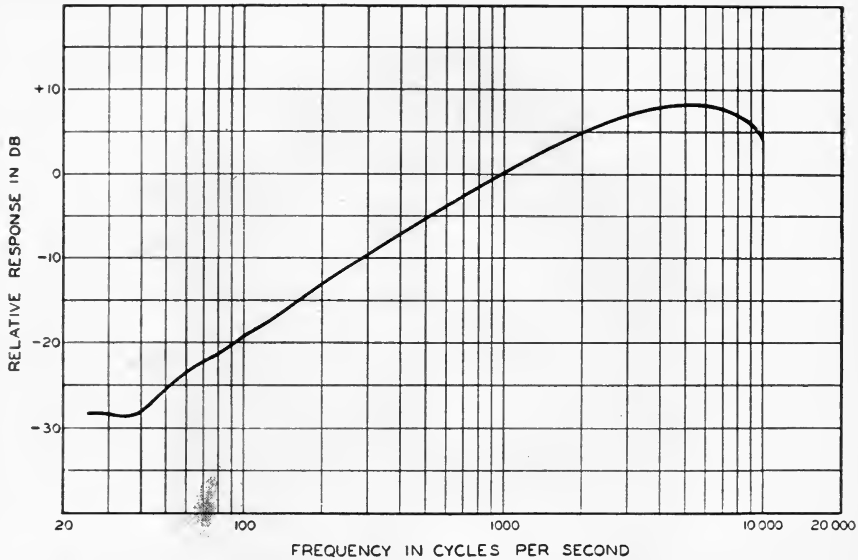


Fig. 7. Frequency-response characteristics of triple-track magnetic head.

To avoid abrupt changes in the track and shield relationship, the edges of the individual shields are especially contoured. This minimizes cyclic amplitude variations in the useful low-frequency-response characteristic. These may otherwise occur at scanning frequencies whose half-wavelengths effectively encounter abrupt changes in magnetic conditions. In this same connection, the departure from a normal 6-db/octave reproducing characteristic lies below the useful frequency range because of the generous film wrap and physical size of the heads.[5] Furthermore, these conditions promote long head life.

The frequency-response characteristic of a typical RA-1508-type head is shown in Fig. 7.

Transmission Equipment

Transmission components and their circuit arrangement have been established after considerable discussion of the general requirements for such equipment with major-studio sound personnel. The cabinet contains all transmission components, including 115-v, a-c power supplies, for operating directly from three mixer outputs when used as a recorder, and for operating into three high-level mixer inputs or power amplifiers when used as a re-recorder, reproducer or playback unit. Since these three transmission channels must be used simultaneously, special care must be taken to maintain the high degree of interchannel isolation provided by the magnetic heads.

When used as a recorder it operates at a nominal signal input of −30 dbm which permits considerable separation from the mixers without line-noise difficulties. It also furnishes direct monitor from each channel at a level of +16 dbm which is sufficient for operation directly into a small monitor speaker or through power amplifiers to a larger horn system. If the mixer operator will monitor from only one channel at a time, leaving to the recordist the responsibility for monitoring all channels simultaneously from the

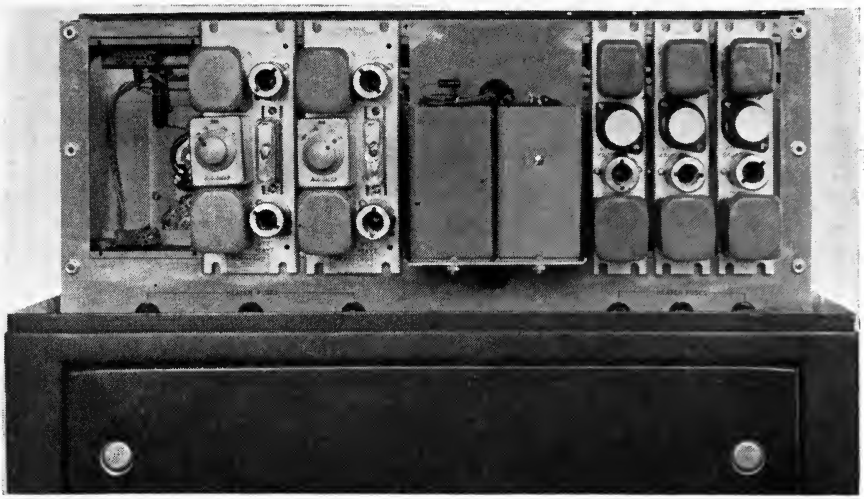


Fig. 8. Plug-in arrangement of amplifiers.

film, he may switch the input of his speaker system to any one of the three +16-dbm direct-monitor circuits. However, if he wishes to monitor two or more channels simultaneously, these may be combined as desired from low-level (−30-dbm) monitor circuits which are also provided. These are bridged from the high-level circuits with sufficient loss such that when combined they will not detract from the 60-dbm isolation figure provided by the heads. It is expected that the mixer operator will not monitor from the film because of the fractional-second delay required for the film to move between the record- and monitor-head positions.

When used as a re-recorder or reproducer, an output from the film of +16 dbm on each channel is provided through the same output circuit as is used for the direct monitor during recording.

The requirement that the three complete recording-reproducing systems, including power supply, be contained within the cabinet calls for special consideration of components and mounting arrangements. Three amplifiers are provided in each channel — one for recording, one for reproducing and an output amplifier used alternatively for direct monitoring or reproducing. For both the recording and reproducing amplifiers the compact RA-1474, as used in the latest Western Electric portable magnetic recording systems, is used.[6] This amplifier uses two miniature 12AY7 vacuum tubes with push-pull output of +22 dbm for 1% distortion. A feature of the amplifier is a plug-in unit which connects to two of the internal high-impedance circuits and provides for gain adjustment in the range from 40 db to 70 db and equalization as required for the particular application. As used in the recording amplifier, the plug-in unit reduces the gain to 48 db and in addition provides a low-frequency pre-equalizer which is used if this equalization has not already been inserted in the mixer circuits preceding this equipment. This pre-equalizer has approximately 4 db of boost at 60 cycle/sec and is complementary to the low-frequency shelf in the reproducing equalizer. In combination, the low-frequency pre- and post-equalizers provide a flat charac-

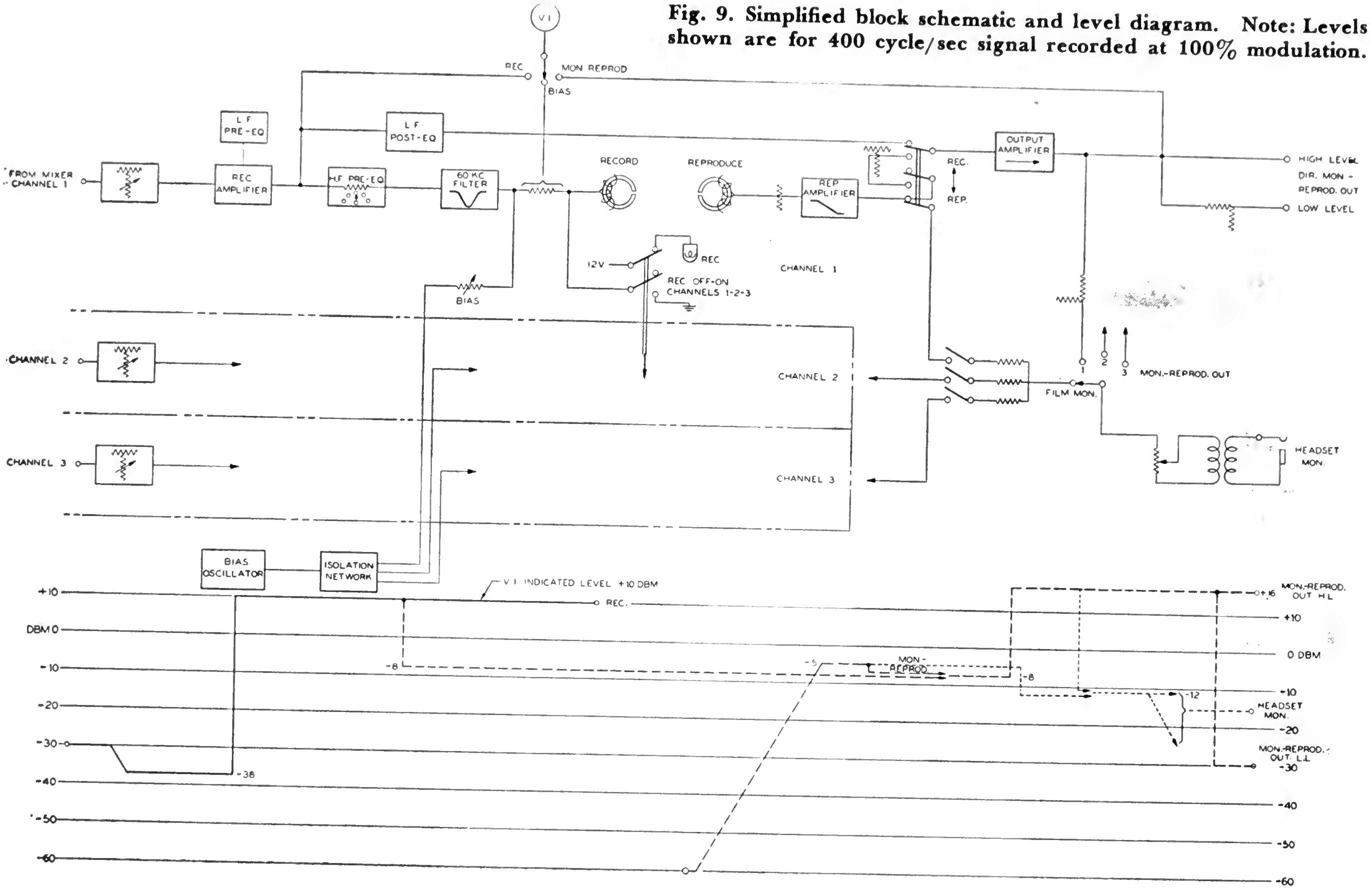


Fig. 9. Simplified block schematic and level diagram. Note: Levels shown are for 400 cycle/sec signal recorded at 100% modulation.

teristic at low frequencies and reduce the effect of power-line interference on the overall signal-to-noise ratio.

In the reproducing-amplifier application, the plug-in unit provides the required 6-db/octave characteristic with the low-frequency shelf as described above, plus a high-frequency shelf compensating for scanning and demagnetization losses.

A new amplifier has been designed to meet the requirement for the direct-monitor and reproducing output amplifier where less gain and greater power output are required than are provided in the RA-1474 described above. As used in this equipment it has a gain of 24 db and an output of +24 dbm with 1% total harmonic distortion. It is also expected that it will have general application as a 600-ohm-line amplifier and a zero-gain bridging amplifier. It is a single-stage push-pull unit using one miniature 12AU7 vacuum tube.

Both types of amplifiers have been equipped with new-type miniature plugs. This permits ready removal or replacement of any amplifier for maintenance or test at a bench position. Separate plugs at opposite ends of the amplifier provide for optimum segregation of low- and high-level circuits throughout the equipment, thus minimizing noise and crosstalk interference.

Figure 8 shows both types of amplifiers in their mountings. Also shown are the slotted guides in the mounting panel which insure registration of the plugs and receptacles. The complete mounting panel for the group of amplifiers is floated, thus making unnecessary the separate isolation of each unit.

The high-frequency bias for the three channels is supplied from one 60-kc-bias oscillator. This eliminates the possibility of audiofrequency beating which could occur with the interaction of three separate oscillators operating at slightly different frequencies. A distribution network from the oscillator output to the three recording-head circuits provides 70 db or more isolation below 6000 cycle/sec for the audiofrequency signals of the three channels which would otherwise be coupled together by the common oscillator supply.

The amplifiers are powered from the RA-1479-type power units as used in the previously described portable recording system.[6] One power unit handles the six record-reproduce amplifiers and the other handles the three output amplifiers. The bias oscillator contains its own separate power supply.

A simplified block-schematic and level diagram of the complete system are shown in Fig. 9. For recording applications, the nominal −30-dbm signal level is received from the mixer and the recording attenuator is adjusted to establish 3% total distortion from the reproduced film for 100% modulation. This normally is obtained with a level of +10 dbm at the recording amplifier output at which point the volume indicator and direct-monitor circuit are bridged. A series network in the head circuit forms the load for the recording amplifier. It also provides high-frequency pre-equalization in five 1-db steps so that with the fixed equalization in the reproducing amplifier a flat overall response is obtained. A 60-kc suppression filter prevents the bias signal from feeding back to the volume-indicator and direct-monitor circuits.

The direct-monitor circuit also contains a low-frequency postequalizer compensating for that equalization introduced earlier in the recording circuit or in the mixer. Under recording conditions it operates into the 24-db-gain output amplifier to provide a flat overall response to the mixer at a 100% modulation level of +16 dbm. Switching arrangements in the volume-indicator circuit permit the meter to be used alternatively for checking levels at the recording-amplifier output, the monitor-reproduce-amplifier output under either

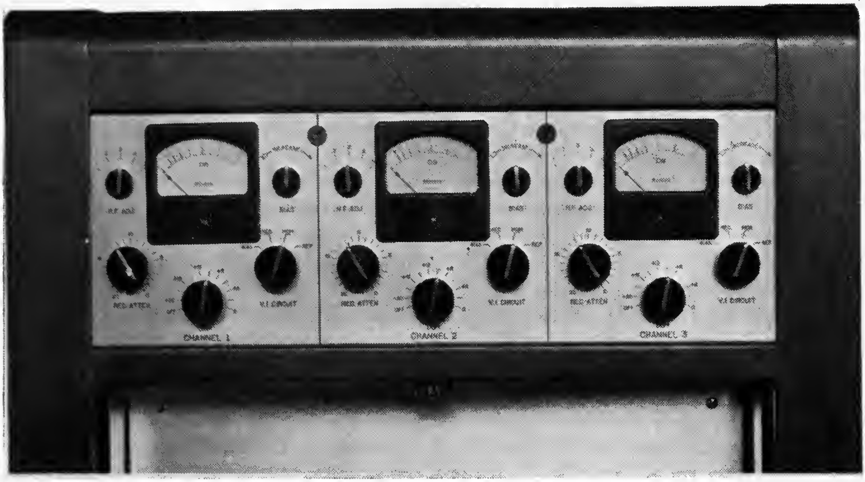


Fig. 10. Control panel.

recording or reproducing conditions and also for measurement of bias current.

The recordist monitors by headset from the output of the three reproducing amplifiers. Normally, if all three channels are being used, he will listen to them simultaneously. In the event any trouble occurs, or for any other reason, he can listen to each one individually or to any combination by operation of the separate cutoff switches. Since these switches are in only the reproducing circuit, their operation will in no way affect the recording. He can also compare the reproduced output from any one channel with the corresponding direct-monitor signal by operation of his monitor-selection switch.

Under reproducing conditions the 24-db-gain output amplifiers are switched to the output of the reproducing amplifiers to provide the +16-dbm output level and the volume indicators are connected across these output circuits.

To prevent the possibility of inadvertent application of the bias- and recording-circuit signal to the film under reproducing conditions, a separate record-reproduce switch operating on all three channels is provided. In the recording position the record and bias circuits are connected through to the head and a red warning light appears on the front panel. In the reproduce position all three record heads are shorted, thus preventing the application of either bias or audio signals.

The principal recording-reproducing operating controls are contained on the front panel covering the upper equipment space. As shown in Fig. 10, the controls for the three channels are identical and are grouped separately. These controls include, for each channel, Record Attentuator, High-Frequency Equalization, Bias Current, Volume-Indicator Meter and Meter-Circuit Selection. Other controls, including those associated with headset monitor and the drive motor, are mounted on either side of the center section of the cabinet.

Performance

The overall performance of the equipment amply meets the requirements for recording and reproducing equipment in major studios. Overall crosstalk isolation between channels, including

heads and all associated circuits, has been maintained at approximately 60 db through the critical middle range of the frequency spectrum.

Based on the allowable 3% total distortion for the complete recorder-reproducer system, the overall signal-to-noise ratio is maintained at 55 db to 58 db, unweighted. The overall frequency-response characteristic is essentially flat over the frequency range from 50 to 8,000 cycles.

Demonstration

A demonstration film has been prepared to show some of the operating characteristics and intended usage of this recorder. In the first part of the film three separate recordings of organ music, boys' choir and dialogue, respectively, are laid down on the three tracks. By switching outputs from the three heads to a single reproducing horn system, the high quality of each recording as well as the lack of interference among associated tracks may be observed. To emphasize further the low-level crosstalk conditions, the center track later in the reel carries no modulation, but the side tracks are heavily modulated. Switching from either of these tracks to the center one reveals no audible evidence of crosstalk.

Conclusion

The machine described in this paper permits the recording of three high-quality magnetic tracks on 35mm film, each one being comparable in quality to that of a single track on 35mm. The residual crosstalk value of −60 db gives, in effect, complete isolation of each track from the adjacent ones, thereby permitting the recording of completely unrelated material on any track. The success of the first units of this machine under studio operating condition presages their wide adoption in the near future for scoring, re-recording and film-storage purposes.

Acknowledgments

The authors wish to express their thanks to the other members of the Westrex engineering staff who have contributed to the success of this development. We wish to express thanks particularly to G. R. Crane for the mechanical design of the double fly-wheel drive, to A. L. Holcomb for the "packaging" of the electronic components, to H. R. Roglin for the testing and alignment of the magnetic heads and to P. F. Thomas for his painstaking testing of the first model of this recorder shown at the Society's Convention at Hollywood, Calif.

References

1. W. C. Miller, and G. R. Crane, "Modern film re-recording equipment," *Jour. SMPE, 51:* 399–417, Oct. 1948.
2. C. C. Davis, "An improved film-drive filter mechanism," *Jour. SMPE, 46:* 454–464, June 1946.
3. W. J. Albersheim, and D. MacKenzie, "Analysis of sound-film drives," *Jour. SMPE, 37:* 452–479, Nov. 1941.
4. J. G. Frayne, and H. Wolfe, "Magnetic recording in motion picture techniques," *Jour. SMPE, 53:* 217–235, Sept. 1949.
5. S. J. Begun, *Magnetic Recording*, Murray Hill Books, New York, 1949.
6. G. R. Crane, J. G. Frayne, and E. W. Templin, "A professional magnetic recording system for use with 35-, 17½- and 16-mm films," *Jour. SMPE, 56:* 295–309, Mar. 1951.

Discussion

John G. Frayne: Before running the demonstration films, which are recorded in such a manner as to illustrate the effective reduction in crosstalk between tracks, I would like to express the thanks of the authors to the engineering and laboratory staff at Westrex Corporation, Hollywood Division, for their invaluable cooperation and assistance in this project. The credit for the invention of the decouplers goes to my colleague, C. C. Davis, and a U.S. patent application has been made in his name for this invention. The Westrex Corporation is pleased to

make this information public since it will undoubtedly stimulate constructive thinking on the part of others and thus will eventually aid in the improvement of the magnetic-recording art.

John P. Livadary: In the Columbia Pictures Sound Department we have been using multitrack magnetic films since November 1950 and we have accumulated a lot of experience concerning the method of compensating for losses in the magnetic re-recording link used in our dubbing operations.

To make it possible to reproduce the same film satisfactorily on any three-track channel, we found it necessary to standardize on the equalization of the reproducing circuits. This, in turn, has resulted in dividing the overall compensation for magnetic losses in two, and in equalizing for part of these losses in the recording and part in the reproducing circuits.

Consistent with this thought, we developed our own standard magnetic frequency film which we use to calibrate the reproducing circuits, the recording circuits being adjusted to achieve a one-to-one overall transfer which is desirable for re-recording purposes.

We have also been using electronic feedback means for the decoupling of crosstalk between adjacent magnetic heads with reasonable satisfaction since November 1950.

L. L. Ryder: One further contribution is that possibly, if the heads are moved a slight distance further away from the drums that may exist on some of the machines, you can still retain the high quality of movement which is desired and get away from a large part of the head wear. We have replaced one or two heads in our work since the advent of magnetic recording. I have in operation at Ryder Services a head which has been operating every day for about two years. It is still not worn out. The angle of approach of the film to the head and the angle of recession of the film may contribute quite a bit to the head wear.

C. E. Hittle: Since our good friend Dr. Frayne of Westrex has volunteered to provide us with information relative to the design of their equipment, as long as their design is covered by patent or patent applications, I have a question to ask relative to the design of their drum assembly, particularly pertaining to the design of the flywheels which they are using on their twin-drum system. Are they of equal mass, weight and size?

Dr. Frayne: Yes, they're identical as far as we know. The combined moment of inertia of the two flywheels is practically the same as the moment of inertia of the single flywheel on the RA1251 re-recorder. That was done so we could retain the same filter components.

M. Rettinger: I would like to ask Mr. Livadary if his electronic decoupling circuit provides crosstalk reduction equal to what was demonstrated this afternoon?

Mr. Livadary: About nine months ago we gave a demonstration, similar to the one given today by Westrex, in which we ran three tracks and cut off each track in turn to demonstrate the amount of leakage which existed. Our measured values of crosstalk suppression at 400 cycles were of the order of about 60 db to 62 db between any two adjacent tracks. At higher frequencies this figure was slightly lower. However, according to our experience to date, having dubbed about 1,000,000 ft of released footage on multitrack magnetic film, we haven't had a single crosstalk problem to cope with, and our decoupling methods have been satisfactory for our work.

Dr. Frayne: When John called me up and told me about this I asked him how it worked. He said that it was mounted in a little black box and that he could not divulge the details.

Mr. Livadary: I regret to reply to Dr. Frayne that this particular method was indeed in a black box at that time and I was more or less on a spot because we were in the process of securing patents which made it difficult to discuss this matter.

Magnetic Sound Track Placement

By LOREN L. RYDER and BRUCE H. DENNEY

This paper sets forth technical data indicating that in magnetic recording on 35mm film, high sprocket-hole modulation is encountered in the area between 50 and 100 mils from the sprocket holes. The paper suggests a change in the proposed ASA standard for 35mm sound track placement.

THIS PAPER is presented after a careful consideration of the present proposed ASA standard for $17\frac{1}{2}$mm and 35mm magnetic sound track placement, Fig. 1. In the opinion of the writers there are two basic reasons why this proposal should not be accepted.

1. Recent tests show a very high percentage of sprocket-hole modulation in the sound track area close to the sprocket holes.

2. The present proposal was prepared prior to active editing of magnetic film and does not adequately meet editorial requirements.

Sprocket-Hole Modulation

The sprocket-hole modulation under consideration is a 96-cycle modulation of the sound signal. In magnetic recording and reproducing this effect is largely an amplitude modulation. It takes place in both recording and reproduction and usually is additive. It is the result of a varying contact and/or lack of contact of the magnetic head with the magnetic coating of the film. There are two primary causes for this variation in contact. During punching of the sprocket holes there is a deformation of the film in the vicinity of the sprocket holes that prevents uniform contact. In winding the film around a drum there is a polygonal effect due to the weakening of the film at the point of punching.

Tests made at Paramount indicate that experts are conscious of about 2% sprocket-hole modulation, that almost anyone will observe 5% and that the distortion becomes quite obvious at 8% to 10%.

A series of tests was made with record-reproduce head widths of 250 mils, 200 mils, 150 mils, 50 mils and a 50-mil head with a land so as to simulate contact of a 250-mil head. Each of these heads was tested at several distances from the sprocket holes. All of these tests were made with full-coated 3-M 35mm magnetic film on a Westrex RA-1231 recorder modified for magnetic recording-reproduction. This is a single drum recorder with the head in the drum. Comparable results were obtained both for the condition of compliant head and fixed head.

Presented on October 18, 1951, at the Society's Convention at Hollywood, Calif., by Loren L. Ryder and Bruce H. Denney, Paramount Pictures Corporation, 5451 Marathon St., Hollywood 38, Calif.

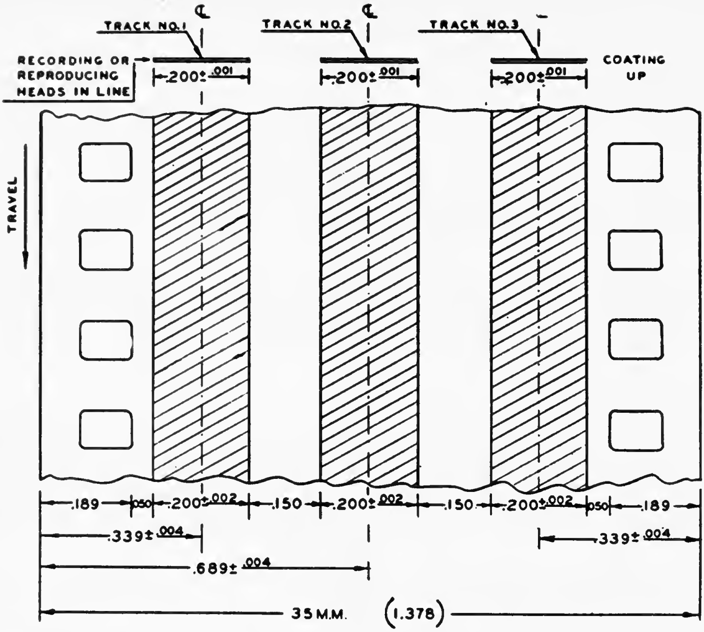


Fig. 1. Proposed American Standard for Magnetic Sound Track Placement. (See Fig. 5A for new recommendation.)

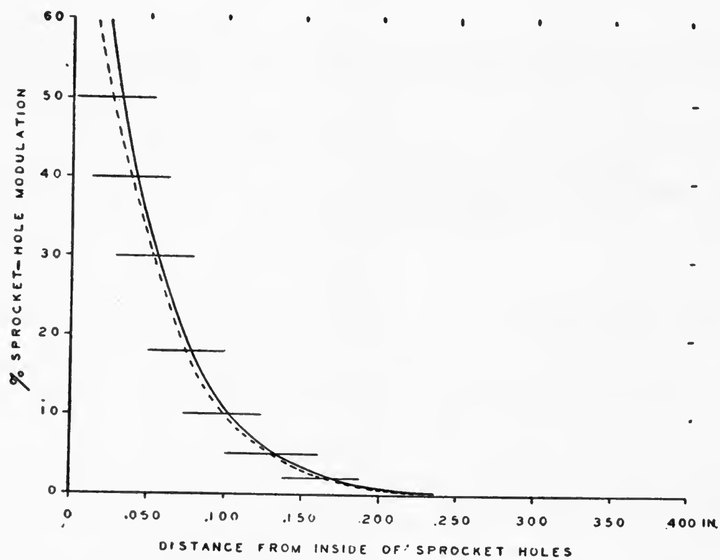


Fig. 2. Record-reproduce 0.050-in. head with 0.200-in. land.

Figure 2 is a plot of the distance of the record-reproduce head from the inside of the sprocket holes vs. the per cent sprocket-hole modulation, using the 50-mil head with a land so as to simulate the contact of a 250-mil head. In this case the slit is toward the sprocket holes and the land is toward the center of the film. On the chart the placement of the slit is shown as a horizontal straight line and the vertical position of the line indicates the per cent modulation for each slit position. A solid line is drawn through the center of the respective slits and a dashed line to the left of the solid line crosses the slits at the point where the per cent sprocket-hole modulation for a small increment of the slit length equals the per cent modulation for the entire slit. The dashed line, therefore, indicates the per cent sprocket-hole modulation actually existent at any distance from the inside of the sprocket holes.

As indicated by the dashed line, the sprocket-hole modulation is 5% at 130 mils from the inside edge of the sprocket holes, 10% at 100 mils, 18% at 75 mils and 32% at 50 mils. In other words, that portion of the film between 100 mils and 50 mils contributes 10% to 32% sprocket-hole modulation. This area is within the scanned area of the proposed ASA standard.

Figure 3 is a plot for a 250-mil record-reproduce head. This shows how the bad sprocket-hole modulation close to the sprocket holes is masked and subdued by the good reproduction far removed from the sprockets. If a 250-mil sound track width is used, starting 50 mils from the sprocket holes, the sprocket-hole modulation will be 3.5% or 4% and the quality will be impaired but marginal. If the 250-mil sound track starts 100 mils from the sprocket holes, the sprocket-hole modulation will be approximately 0.5%.

Figure 4 shows the per cent sprocket-hole modulation for a 50-mil (A), a 150-mil (B), a 200-mil (C) and 250-mil (D) slit, each starting 100 mils from the sprocket holes. Similar information is shown at E, F, G and H for slits starting 50 mils from the sprocket holes. Line G represents the present proposed ASA standard (a 200-mil record-reproduce head starting 50 mils from the sprocket holes) which averages 5.6% sprocket-hole modulation. Previous measurements made by others and submitted to the Motion Picture Research Council indicate a sprocket-hole modulation of 4.5% for this condition.

Line B shows that a 150-mil head starting at 100 mils from the sprocket holes and extending to the same inside line as the proposed ASA standard (right-hand end of both lines G and B), will reduce the sprocket-hole modulation from 5.6% to 2%. The loss in level is approximately 2.5 db.

For both 35mm and 17½mm recording the writers recommend the sound track placement shown in Fig. 5A. Fortunately, this placement also meets the editorial requirements which are set forth in the second part of this memorandum. It is further recommended that heads be aligned so that the end of the slit shall be 131 mils from the inside edge of the sprocket holes and that this condition shall prevail regardless of the length of the slit in the head. Referring to Fig. 2, this 131 mils is the point at which the incremental measurement is 5% and any further encroachment toward the sprocket holes is undesirable.

In this recommendation the sound track is 200 mils wide; however, any width head can be used and the recordings played on any width head as long as the alignment is as outlined above. Paramount has many 250-mil heads which will remain in service.

It is to be noted that recordings made on the ASA proposed standard will reproduce better under the conditions of this recommended procedure than on the ASA proposed standard. Further, recordings made on the basis of this

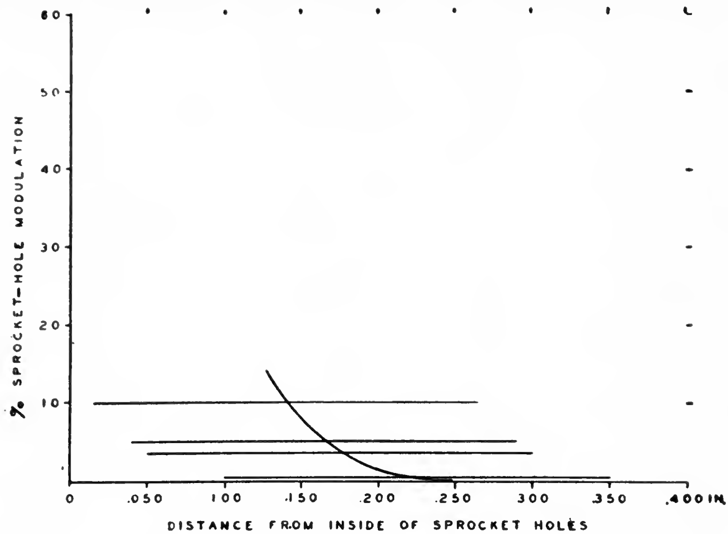


Fig. 3. Record-reproduce 0.250-in. head.

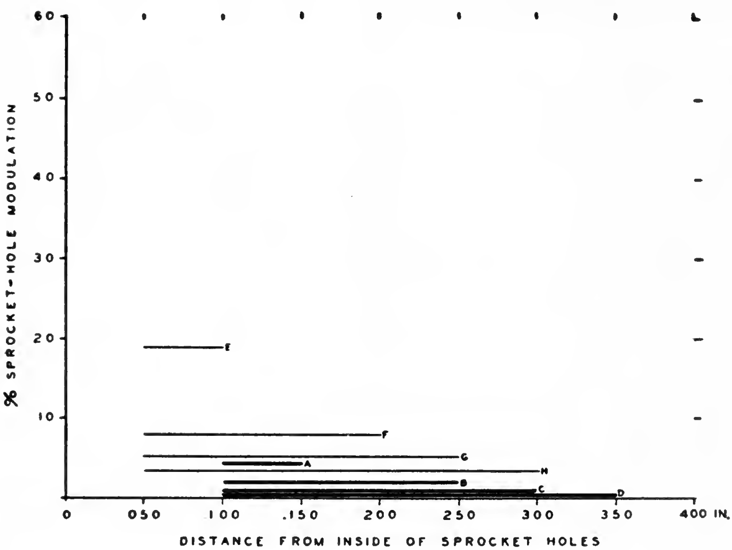


Fig. 4. Comparative sprocket-hole modulation — slits starting 50 mils vs. slits starting 100 mils from sprocket holes.

100 mils	*50 mils*
A, 50-mil head	E, 50-mil head
B, 150-mil head	F, 150-mil head
C, 200-mil head	G, 200-mil head
D, 250-mil head	H, 250-mil head

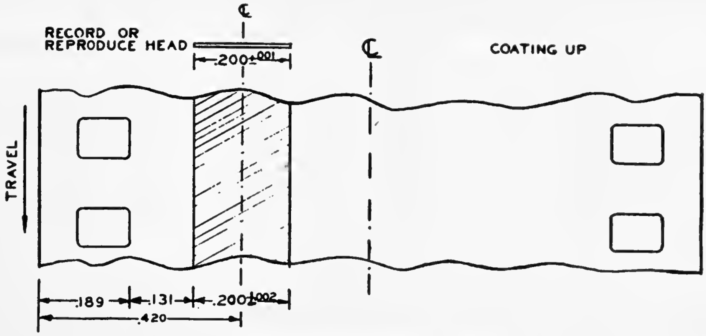


Fig. 5A. Recommended sound track placement.

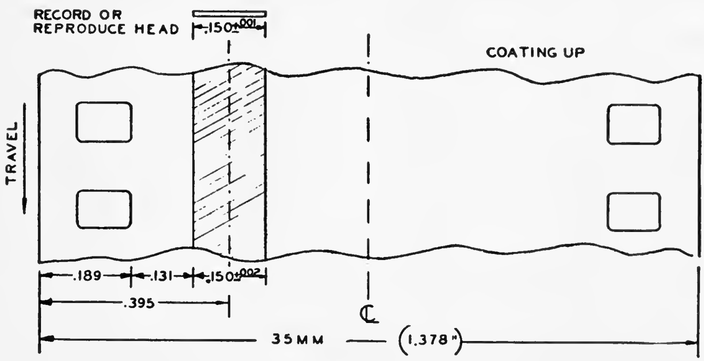


Fig. 5B. Alternate sound track placement for 150-mil head.

recommended procedure will reproduce better on the ASA proposed standard than a recording made and reproduced on the ASA proposed standard. In other words, whenever the work and/or equipment used is intermingled between old and new, the result is always improvement and never degradation.

If existing equipment is to be modified and if the 200-mil head cannot be moved to the position specified in Fig. 5A, most of the improvement can be gained by using a 150-mil head as shown in Fig. 5B.

It is expected that all three-track recordings will be done on full-coated magnetic film, although the future may show a preference for striped film having a clear area between each stripe. For three-track recording the writers recommend the sound track placement shown in Fig. 6A. If greater track-to-track isolation is desired, the placement (Fig. 6B) can be used. Either of these proposals will have less sprocket-hole modulation and less distortion than the ASA proposed standard.

As indicated earlier in this memorandum, the tests were made with full-coated magnetic film on equipment having the head in the drum. This is the basis on which the original standardization was contemplated and is the condition of most magnetic recording. Tests which have been made show a slight preference in favor of magnetic film that is not coated in the sprocket-hole area and also there seems to be some

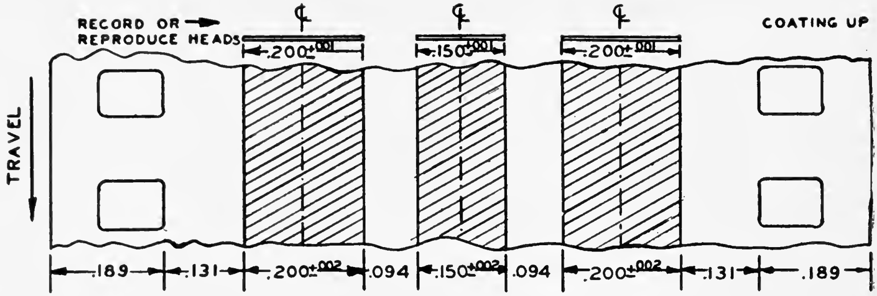


Fig. 6A. Three-track recommendation.

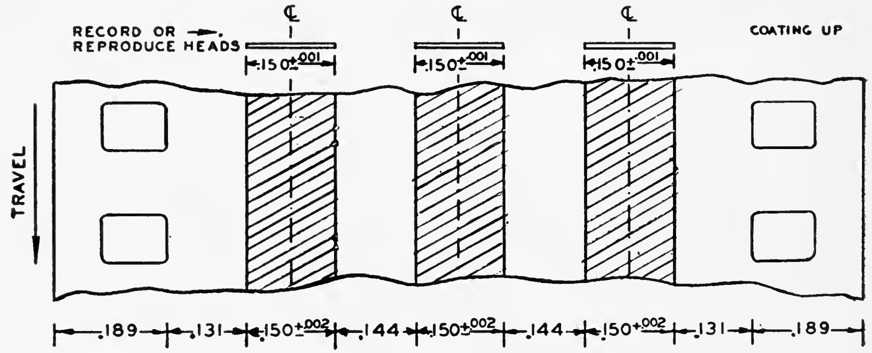


Fig. 6B. Alternate for three tracks.

improvement with recorders of the two-flywheel type. However, as most of the equipment and most of the magnetic film used are the type used in this test, the standard should meet these requirements. Listening tests made subsequent to the above measurements indicate that under certain conditions of single-drum handling of 17½mm magnetic film, sprocket-hole modulation is greater than with 35mm magnetic film. As far as the writers know, no measurement studies have been made of this effect, even though over half of the production recording is on 17½mm magnetic film.

The tests reported in this paper were made by recording a 3072-cycle frequency on the film and observing the ratio of peak amplitude of 96-cycle to 3072-cycle reproduction on an oscilloscope. Previous measurements made with the harmonic wave analyzer also included film irregularities and were found to be misleading at these relatively low percentages. Intermodulation analyzers include the other film irregularities in their measurement and are, therefore, not indicative of 96-cycle, sprocket-hole modulation. The percentage of 96-cycle modulation is almost independent of signal amplitude.

In general, the sprocket-hole modulation described above has gone unnoticed and has caused little trouble in recording. This is because most companies are still working with only first copy transfers or intermediate film procedures. These modulation effects will become more obvious when film

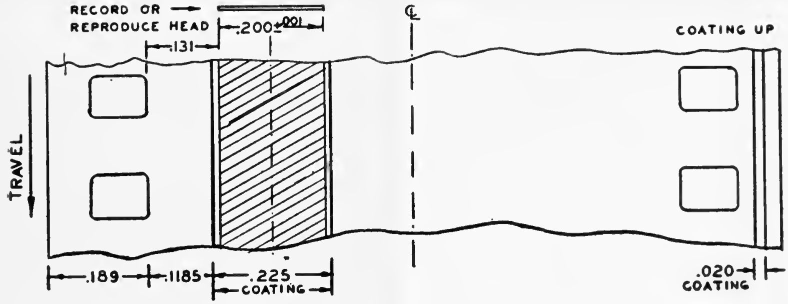


Fig. 7A. 35mm magnastripe.

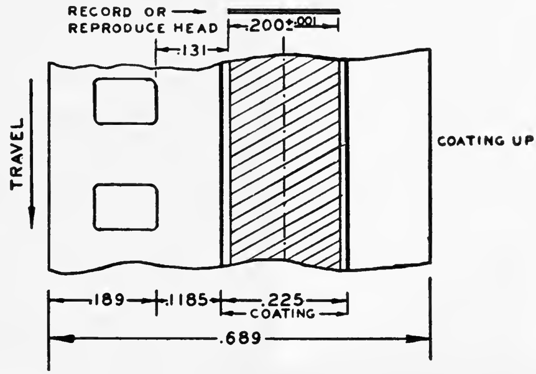


Fig. 7B. 17½mm magnastripe.

losses are eliminated from the procedure and when the number of generations is increased. The reason why many people prefer ¼-in. tape as compared to sprocket-driven magnetic film is because of sprocket-hole modulation. We should not accept a standard that limits future development, especially when a better standard is available without increased cost and without damage to the recordings already made.

Editorial Handling

Sprocket-driven magnetic film may be assembled and handled in simple editing much the same as ¼-in. magnetic tape. However, most motion picture editing involves so much overlapping, modulation matching and selecting of the best place to cut that a more positive system seems desirable.

Experience at the Paramount West Coast Studio and Ryder Services indicates that some form of visual modulation is essential to convenient cutting of magnetic film. The initial work with modulation writing* on the magnetic coating was a step in the right direction; however, it required front viewing of the modulation writing, whereas editors are equipped for and are in the habit of viewing both picture and sound by transparency.

After checking all combinations of sound track placement and every known

* L. L. Ryder, "Motion picture studio use of magnetic recording," *Jour. SMPTE, 55:* 605–612, Dec. 1950.

Fig. 8. Magnastripe film placed on top of picture film for synchronous handling.

form of modulation writing, Paramount and Ryder Services have selected the striped magnetic film shown in Fig. 7A for 35mm editorial work. This has a stripe of magnetic coating 225 mils wide with center line 420 mils from the edge of the film. A 20-mil stripe is placed near the sprocket holes on the side of the film opposite the sound track so as to balance the roll for winding. Figure 7B shows a coating of magnetic film for $17\frac{1}{2}$mm use. In manufacture two stripes of magnetic coating are placed on 35mm film and later slit to give two $17\frac{1}{2}$mm films.

For both 35mm and $17\frac{1}{2}$mm editing, the modulation writing is placed on the film in the clear area between the striping and the sprocket holes. An illustration of the 35mm film along with picture is shown in Fig. 8.

By reviewing Fig. 8 it will be noted that:

1. When the picture and sound films are placed on top of each other, the modulation can be seen by transparency through the clear area of the picture. This procedure is a common editorial practice with optical sound film.

2. The picture can be seen by transparency through the clear area of the sound film. The area available for viewing is the same as under the present practice with 200-mil, push-pull optical recording.

3. The code numbering used for synchronization can be viewed in transparency and matched.

4. The picture and sound film still held together can be run through a picture-only or sound-only magnetic Moviola unit.

5. Markings can be made on the film in crayon or ink and read in transparency as at present. Crayon markings should not be made in the sound track area.

6. These films can be handled in regular existing editorial equipment including synchronous rewinds. The only conversion necessary is the magnetic reproducer on the Moviola and a magnetic reproducer or conversion for the review room.

7. These films can be handled by the existing editorial techniques which have

been evolved after many years' practice and experience.

8. The magnetic cutting print is also used as the dubbing print.

9. The modulation writing is on the base side of the film and can be removed with carbon tetrachloride.

10. The film can be erased, cleaned and re-used many times.

11. The magnetic sound track placement leaves the photographic sound area clear. This makes it possible to intercut magnetic and photographic sound films.

12. It is also possible to stripe photosensitive film either before or after processing. Under this proposal it will, therefore, be possible to have both photographic and magnetic sound on the same piece of film. This may be of great value in newsreel work, narration recording and editorial processes, including scoring and dubbing.

13. For most reproducers these films can be spliced on hot-lap splicers if the blades are demagnetized.

Many combinations of sound track and modulation writing position have been tried and abandoned. There may be a slight advantage in favor of having the sound track in the so-called positive position instead of the so-called negative position. This would involve so many changes in equipment that it is not recommended. In these considerations we have also reviewed the question of under- vs. over-scanning of striped magnetic film. Practice to date indicates that there is no preference.

General

Fortunately the best-known specification for editing is the correct specification in regard to sprocket modulation.

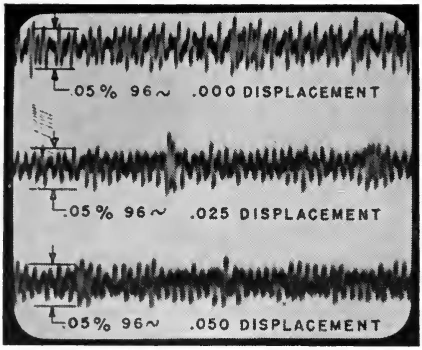
Paramount West Coast Studio and Ryder Services, along with a goodly number of the recording companies, have from the inception of magnetic recording used a sound track placement such that the center line of the sound track is halfway between the inside of the sprocket holes and the center of the 35mm film. We are abandoning these specifications in favor of the new suggested procedure. We hope that others in the industry will take advantage of our work. We have no hesitation in taking this step because, as stated earlier, films can be interchanged and any film that is either recorded or reproduced in accordance with this suggestion will play better than a film that is both recorded and reproduced under conditions of the ASA proposed standard.

We urge that the Society of Motion Picture and Television Engineers and the Motion Picture Research Council reject the present proposed ASA standard and along with other possibilities consider the suggested procedure set forth above.

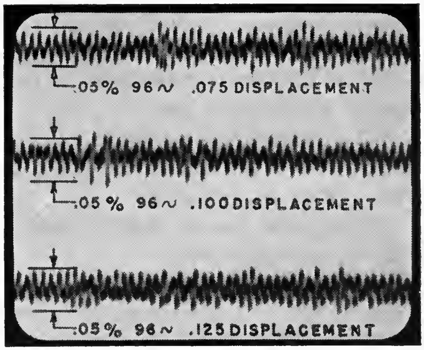
Discussion

J. L. Pettus: It appears that the experiences by us at RCA do not quite agree with Mr. Ryder's. In fact, some of our data might take exception by as much as ten to one. With your permission, I would like to illustrate a point or two by the use of a few slides. These slides consist of measurements of 96-cycle flutter as well as amplitude modulation and I would like to present them in view of the statement Mr. Ryder made that his method of evaluation was (1) by listening and (2) by measuring, and in view of the method by which he measured. Possibly we take exception to the method of measuring.

At the top of Slide 1 is an oscillogram of 96-cycle flutter measured from a



Slide 1.



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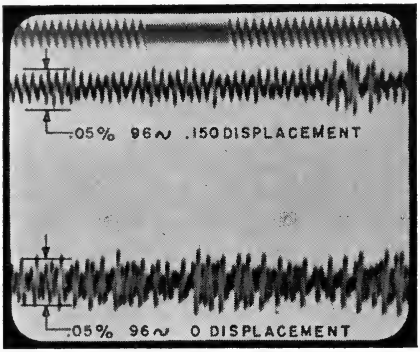
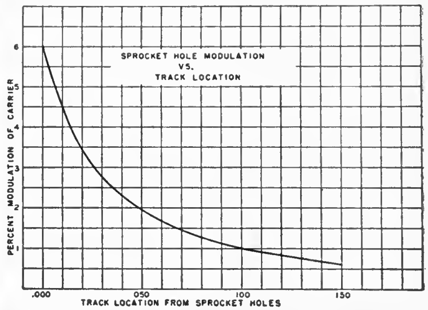


Slide 3.



Slide 4.

3000-cycle tone recording where the magnetic track was laid down at a 0 displacement from the sprocket hole. In other words, the edge of the track was directly adjacent to the perforations. The second oscillogram was made with the head moved over 25 mils. You will note in the first, that the average value of 96-cycle flutter is somewhat greater than 0.05% and when the head is moved over 25 mils, the average value drops a little less than 0.05%. In the third oscillogram, the head was moved over 50 mils and the same amount of 96 cycles seems to prevail. Slides 2 and 3 show a continuation of flutter measurements where the head was moved in increments of 25 mils and measurements were taken at 50-, 75-, 125- and 150-mil displacement. Again, the amount of 96-cycle flutter shows little or no change over that shown in the second oscillogram where the head is just removed from the perforations. Slide 4 deals with the measurement of amplitude modulation as indicated on an intermodulation set reading only the amplitude variations. Here we notice that the top of our curve shows a value of 6% modulation of the carrier and may be compared to that in Mr. Ryder's illustration which, I believe was approximately 60%. Our measurement at this point was taken when the track had a 0 displacement from the perforations. Now, if we move over 25 mils, we find 3.5% modulation followed by 2% at the 50-mil displacement and

1% at the 100-mil displacement. It is seen that the curve flattens out rather quickly. If the signal is raised in frequency to, say, 7000 cycles, this entire curve moves slightly toward the perforation base line and also increases its height. Judging from these data, we see no real gain in changing the proposed standards, but instead, we see several complications arising in the use of triple tracks and at the moment I have not seen Mr. Ryder's proposal on how he would arrange three tracks along the 35-mm film in satisfactory manner.

Dr. J. G. Frayne: I think Mr. Ryder's figure of 60% was based on a 50-mil track rather than a 200-mil track that Mr. Pettus's figures were based on. Is that right?

Mr. Pettus: That is correct. Those tests were made on standard 200-mil track.

L. L. Ryder: Please refer to the Slide 4 which was presented by Mr. Pettus. The graph line indicates the percentage of sprocket-hole modulation for different positions of head placement with respect to the sprocket holes. At a position of the head such that the end of the slit is 50 mils from the sprocket holes, the sprocket-hole modulation is shown as 2%. Now, please refer to Fig. 3 in my paper. This happens to be for a 250-mil head and the reading of sprocket-hole modulation is approximately 3.5%. The data, therefore, are not out of agreement by a ratio of 10 to 1, as indicated by Mr. Pettus, but by a ratio of 3.5 to 2, which is 1.7 to 1.

Now, referring to Fig. 2 in my paper, it is to be noted that at 50 mils from the sprocket holes the incremental sprocket-hole modulation is 32%. If this is to be reduced by the factor of 3.5 to 2 to conform with the RCA data, the amount of sprocket-hole modulation introduced would be 18%. It is my feeling that we should not introduce 18% sprocket-hole modulation in order to meet a proposed standard.

The validity of our measurements has been questioned. We believe our measurements to be correct, but in any case our measurements have been related to what can be heard, and what we can hear is the thing about which I am most concerned. Our first observations of this phenomena were the result of listening tests made with the proposed ASA standard. Both the RCA data and the data prepared by the writer indicate that a change should be made.

F. R. Wilson, Vice-chairman of the Session, read a communication from L. D. Grignon, Twentieth Century-Fox Film Corp., reporting data from an investigation of 96-cycle modulation made recently on regular production equipment:

"Recordings were made on a Westrex RA-1231 recorder modified for magnetic recording, using a 250-mil track with the nearest edge 50 mils from the sprocket hole. This recorder uses a compliant mounted head adjusted to 90-g pressure and a special recording drum which supports as much of the film as possible. A signal frequency of approximately 3000 cycles was used at a level which produces 1% harmonic distortion. During reproduction the output was observed on an oscilloscope by the same method as reported by Ryder and Denney, the exact signal and sweep frequencies being adjusted to give the most readable traces. Since the peak-to-peak 96-cycle modulation is of the order of 3%, the reading error was considerable due principally to random amplitude fluctuations and noise; therefore, readings of total peak modulation distortion products were made by the use of an Altec TI 402 intermodulation analyzer. Two film stocks were used with the results shown in Table I. When the 96-cycle modulation is less than 2.5%, the oscilloscope reading accuracy becomes seriously questionable and, therefore, in some instances data are recorded only for the intermodulation analyzer measurement.

Table I.

Recorder	Reproducer	Oscilloscope % 96-cycle peak modulation	Intermod. analyzer % total (peak)	Notes	
RA 1231	RA 1231	3.3	4.0	Roll 9601	Old film
RA 1231	RA 1251	2.5	3.5	Roll 9601	Old film
RA 1231	RA 1231	—	1.2	Roll 1336	New film
RA 1231	RA 1251	—	1.2	Roll 1336	New film
RA 1251 (3-track)	RA 1251 (3-track)	—	1.2	Roll 1336	Track 1 (outside)
RA 1251 (3-track)	RA 1251 (3-track)	—	1.7	Roll 1336	Track 2 (center)
RA 1251 (3-track)	RA 1251 (3-track)	—	1.0	Roll 1336	Track 3 (inside)

Table II. Recorded on RA 1231 and Reproduced on RA 1251.

Magnetic film roll no.	Date first used	Approx. no. of times used on prod.	Oscilloscope % 96-cycle peak modulation	Intermod. analyzer % total (peak)	Remarks
9596	12–31–49	10	2.0	1.9	Many random variations
9915	2–2–50	12	1.80	1.8	
0607	4–1–50	7	2.60	2.6	
1415	5–19–50	9	2.10	2.0	Many random variations
1563	5–22–50	9	1.75	2.2	
755	10–17–50	5	2.20	1.9	
6650	11–29–50	6	1.75	1.7	
925	3–8–51	5	1.25	1.4	
1010	3–26–51	3	1.5	1.5	
1298	9–7–51	1	2.0	1.7	

"The considerable differences between the two stocks prompted another series of measurements of the same kind on a variety of stocks. These results are shown in Table II with pertinent historical data concerning each roll. From Table II it may be concluded that: (1) with the recording and reproducing equipment used at the subject studio and the magnetic film stocks currently in use, the maximum total amplitude distortion products do not exceed 2.6% (Note — Roll 9601 of Table I is used only for preliminary maintenance tests); (2) there has been some improvement during the past 1½ years, due either to reduced random amplitude irregularities or improved perforations; and (3) there is little correlation between usage and amplitude distortion products.

"It can be expected that the amplitude distortion products due to 96-cycle modulation will increase in some fashion when multiple generation recordings are made from a given piece of material, but this is also true of all other amplitude irregularities, noise and flutter. The number of good-quality generation records which can be made is determined

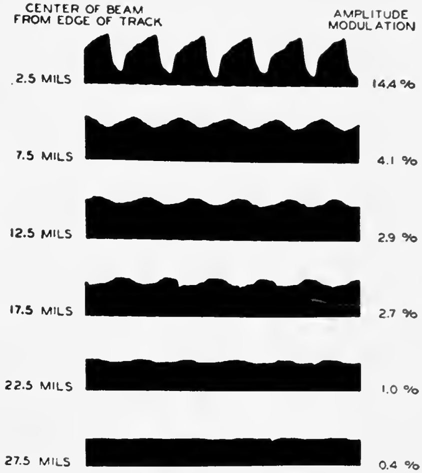
by all these factors, not by 96-cycle modulation alone.

"Considering the data and the particular equipment in use at Twentieth Century-Fox, it appears that a change in track position to some location other than the standard now proposed by the Society would be of very questionable merit. It would seem that the greatest benefit can be obtained by film improvement, particularly with respect to uniformity of high-quality perforation and low-valued random amplitude irregularities."

Mr. Ryder: As an operator and as a director of sound activity in the making of motion pictures, it is not my good work that causes me trouble but my bad work. I am, of course, very concerned about test data. I do want the data to be correct and accurate, but with respect to what I put in my plant, and I should think this would apply to others, I want first of all that it cause me no trouble. The Fox data show 3.5% to 4% sprocket-hole modulation on old film. These data correspond almost exactly to the data shown in Fig. 3 in my paper, which in turn indicates to the writer that an incremental measurement on the Fox equipment would correspond to Fig. 2. I should, therefore, expect Fox to be able to hear the same sprocket-hole modulation that we are able to hear at Paramount.

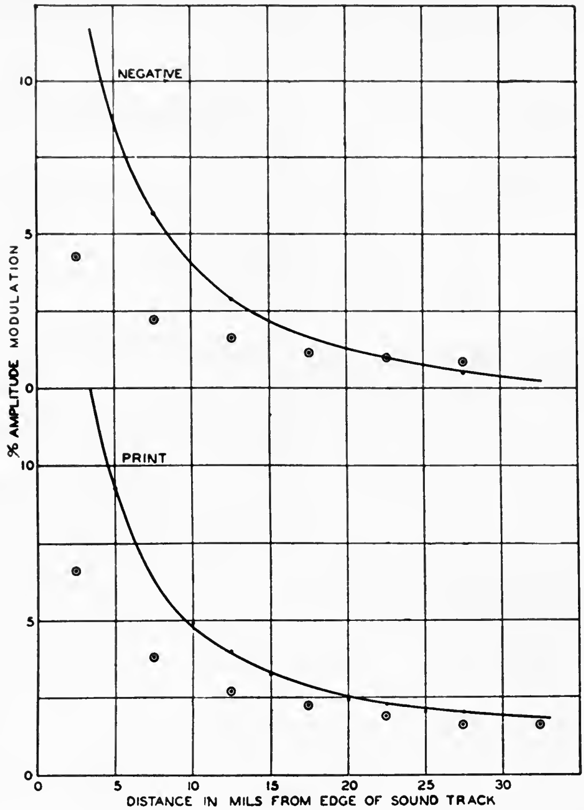
It is my belief that all users of magnetic recording contemplate the re-use of film, which means the use of old magnetic film. In the taking of our data we found variations and inconsistencies between batches of magnetic film. The sprocket-hole modulation of old films is generally higher than that of new film. These are the films that can cause trouble and this is the trouble that can be avoided by changing the proposed standard.

Dr. Frayne: It is interesting that information presented by Mr. Pettus was made on films using a double-flywheel-type drive, whereas Mr. Grig-



Slide 5.

non's information was obtained on a recorder using the single-drum-type drive with the head located at the drum. So we have two different philosophies of film drive and the results are more or less comparable. Therefore, what is wrong with Mr. Ryder's data? First of all, 96-cycle sprocket-hole modulation is nothing new and is not confined to magnetic film. I wrote a paper on this subject in 1935 and if we may have the first slide (Slide 5 in this printed version) I can show you some of the things we found on a typical negative photographic sound track. This was done not with a 50-mil head, but rather with a 5-mil head. At 2.5 mils from the sprocket holes (in other words, the center of the 5-mil head was 2.5 mils from the edges of the sprocket holes), we got severe amplitude distortion on a 3000-cycle track. At 7.5 mils the amplitude modulation was a little better, at 12.5 mils a little better yet, and at 27.5 mils it had just about disappeared. I'm not claiming that the amount of sprocket-hole modulation you get in photographic is identical in amplitude to what you get on magnetic due to the greater depth of focus on photographic, but on the other hand the trend is there showing



Slide 6.

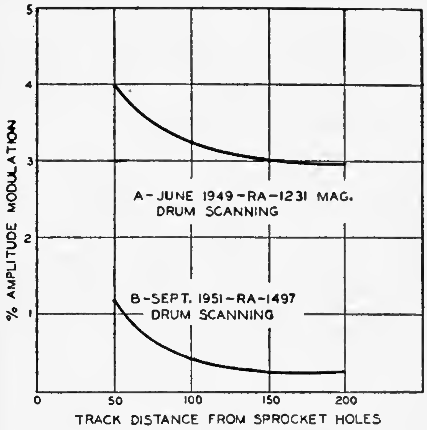
how it varies as it moves in from the sprocket-hole edge. Photographic recording is all recorded on a drum and reproduced at a drum; therefore, the conditions as far as polygoning are concerned are the same. This effect shown here was not due to any laboratory effect. The negative track described above and the resulting print were developed in a special tank which eliminated any laboratory development sprocket-hole modulation.

Slide 6 shows plots of results. There are two methods of measurement. The heavy solid curves were taken on a microphotometer, which took in all the peaks. The dotted points are the measurements made with a device which is quite similar to the modern intermodulation analyzer. And you will notice, disregarding the amplitude because it shouldn't necessarily be the same in photographic as magnetic, that the effect flattens off pretty much around 25 or 30 mils. Based on this information we set up, in cooperation with MGM, the 200-mil push-pull track in the so-called offset track position. Now the intermodulation analyzer, when used to measure amplitude modulation, measures not only 96, it also measures everything else. The statement, made in Mr. Grignon's contribution above, that they got 4% on old film was used by Mr. Ryder as favoring his case; but it doesn't favor his case at all because

there is no reason at all why 96 cycles should be affected by old film. The old film is contributing the hash, the 96 is very much the same. I see no reason why the 96-cycle should change appreciably. If you're going to use old film, you're going to get more amplitude modulation of a general nature.

Dr. Wolfe and I set the track position at 135 mils which incidentally is what Mr. Ryder is proposing now. We found that it was a very good position to operate in because sprocket-hole modulation was at a minimum. And we would have been very happy to stay at 135 mils, if we hadn't had this kaleidoscopic Hollywood, this ever-changing situation to contend with. We no sooner got it set there when up came John Livadary with his bright idea of three tracks on 35mm film. As a result, RCA and ourselves got together to study where we could put these tracks. Westrex thought that 75 mils in from the sprocket-hole edge would be a good compromise. At first nobody worried much about the crosstalk between adjacent tracks. But when it was decided to use these tracks for storage of three independent films the situation began to get fussier as to crosstalk, and as a result we had to work out a wider separation of the tracks, resulting in the outer tracks being located 50 mils in from the sprocket holes.

At that time, in 1949, we measured amplitude modulation products and the information was presented orally to the Research Council. I would like now to show a slide (No. 7) which will show the measurements we made in July 1949 on amplitude modulation with the film as it was in those days. The upper curve was made on the RA-1231 Magnetic Recorder drum and at 50 mils in it shows 4%, but it dropped very little until we went in as far as 200 mils. It never dropped much below 3%. In other words, it looked like it would never get below 3% no matter where you located the track. The only conclusion I could draw from that was that the



Slide 7.

residual amplitude modulations undoubtedly came from scratches and dirt and hash. Now since Mr. Ryder made his proposal to change the proposed standard we repeated the measurements in September 1951. This time we used our new RA-1497 Recorder with drum scanning. There are some significant differences. The drum size is greater on the 1497 than it is on the 1231 and we know from previous studies that sprocket-hole modulation is generally more severe with small drums. It's also a matter of film tension. In the case of magnetic recording it is also a function of the tilt of the head. We obtained the lower curve shown in Slide 7. You will notice that at 50 mils in we get slightly over 1% which agrees with Mr. Grignon's contribution.

Mr. Ryder has said that amplitude modulation experts could hear 2%, halfway experts 5% and the public 10%. There are no published data, although the Bell Labs did some work on this problem, on how much amplitude modulation a person can hear. First of all, it depends on many factors, the frequency that is being modulated, whether it's 100 cycles, 1000 or 10,000. It also depends on the modulation rate, just as flutter does. I tried to work out

something that might help us see what would be the minimum we could hear. With an amplitude modulation of a carrier only two sidebands are produced. If you have, say, 20% amplitude modulation, 10% lies in each sideband. In flutter, on the other hand, which is an FM type of modulation, one obtains an infinite series of sidebands, that is, if the modulation index is high enough. When the modulation index is low enough in FM you also get only two sidebands. So it's natural to suppose that a flutter having this index of modulation would sound to the ears just like an amplitude modulation having the same sidebands. Now, the maximum value of the modulation index at which you can neglect the higher orders of sidebands in FM is of the order of 0.025, the first-order sidebands being about 10% of the carrier. This index of modulation is designated by the Greek letter α.

Now,

$$\alpha = \frac{\Delta f_0}{f_m}$$

where

Δf_0 = frequency deviation of the carrier

and

f_m = the modulation (i.e., flutter) rate.

Substituting:

$$\alpha = 0.025 \text{ and } f_m = 96,$$

$$\Delta f_0 = 2.4 \text{ cycles}$$

The flutter in a 3000-cycle tone is given in % by:

$$\text{flutter} = \frac{2.4 \times 100}{3000} = 0.08\%$$

We noted previously that for this flutter condition the first sidebands were 10% of the carrier. In the case of amplitude modulation, this corresponds to a value of 20% since one-half, or 10%, lies in each sideband. Similarly, a 10% amplitude modulation corresponds to a peak value flutter of 0.04% at the 3000-cycle rate. Now, this is about as good a commercial film reproducer as can be built and it would seem to signify that 10% amplitude modulation would be largely inaudible, at least at 3000 cycles.

What minimum 96-cycle flutter can be detected is somewhat controversial. It depends on the person and it depends on the room in which the tone is being heard. Manufacturers of sound-recording equipment have tried to keep 96-cycle flutter somewhere between 0.05% and 0.1% and we think 0.05% is pretty good. It would appear, therefore, that we could similarly tolerate 10% amplitude modulation. Since our graphs show a little over 1% in new film, we do not feel that there is any great problem in the proposed location of the track.

Mr. Ryder: With respect to the optical versus magnetic comparison of sprocket-hole modulation, it should be noted that with optical film as long as there is a signal across the film, it is seen by the photoelectric cell. Sprocket-hole modulation on optical film is the result of a change in photosensitivity due to punching, a change in the developing effect near the sprocket holes due to agitation, and polygoning. In magnetic recording and reproduction the effect that we are noting is a result, partly at least, of deformation from punching which causes a fluctuation in magnetic head contact with the film. All one has to do is hold the film in reflected light and observe the deformation from punching.

There is another phenomenon that has been observed — that the effect of sprocket-hole modulation varies with frequency. We have not searched for the point where the highest modulation takes place. We should expect the modulation effects to be greater at higher frequencies and lower in the 2000-cycle range where the more recent Westrex tests were made.

With respect to the old films, our definition of old film as presented here a few minutes ago is not so much a

question of age in time as a question of age in usage. By examining film that has been used many times, the sprocket wear and deformation are quite obvious, which can only increase rather than diminish the problem. At Paramount and at Ryder Services, where we are using the sound track placement suggested here, we use old films interchangeably with new films and have noticed no bad effect. We see no reason for buying new film because of any deterioration of the film or from the standpoint of the hash mentioned by Dr. Frayne.

I do not have data to show the effect of increase or decrease in this hash. I should point out, however, that the system of measurement used by Paramount separates sprocket-hole modulation from the so-called hash; whereas all of the other data presented at this meeting combine sprocket-hole modulation and so-called hash to the point of confusion. As pointed out in my paper, Paramount changed from the distortion and intermodulation type of measurement to the use of the oscilloscope in order to avoid this measurement trouble.

I should expect that in the future we might develop recording machines and magnetic film which will have less sprocket-hole modulation than we are now encountering. We have presented this paper on the basis of a recorder under normal present-day conditions of operation. If we were to repeat these measurements as we have in the past on several occasions, our results would be the same.

I concur with the mathematics which Dr. Frayne has placed on the blackboard. I was careful and punctuated my wording with respect to our observations of percentage modulation and made it clear that these observations were under our conditions of use and measurement. Our first concern is what we can hear, what can be heard by the average person and what annoys the average person. Our measurement data are related to these observations. It is my feeling that any measurements and any data which are tied into flutter modulation may be quite different from that which is now taking place with respect to amplitude modulation. Many people are confusing these two types of modulation. We were confused at first, but it is quite clear to us now that our concern is amplitude modulation which, incidentally, can be additive along with generations of transfer. When each generation of transfer adds up in the same direction, you can gain a very high percentage of sprocket-hole modulation. Unfortunately, they never completely cancel. Again I say, it is the occasional bad quality and not the good quality that causes us trouble. We are endeavoring to eliminate the occasional bad quality. We hope that this elimination will also improve the good quality.

We present this information to the Society of Motion Picture and Television Engineers and the Research Council as a study which we have made in all sincerity with the thought that the knowledge that we have gained should be made available to all. The utilization of this knowledge, its acceptance or its rejection, is up to the Society and the Research Council.

I should clarify one point and that is I doubt if Paramount will move over to 50 mils from the sprocket holes. In any case, Paramount will make its recordings and reproducers so that they can be played interchangeably with whatever standard is finally accepted. I am very much opposed to getting into another turmoil of the type that now exists on 16mm work.

Mr. Mueller: I think it is time that you should hear from the Sound Committee of the Research Council who drew up these present standards and who presented them to the SMPTE. These proposed standards were published in July of 1951.

You have heard the pros and cons as presented here which is really an extension of the discussion in our committee, as most of the information shown today was gathered at the request of our committee and discussed thoroughly at meetings extending over more than two years. We finally decided that it was very important to all of us that no more delays be tolerated and that the magnetic standards favored by the vast majority of the committee be adopted.

Speaking as a member of the Sound Committee of the Research Council and as its present chairman, I want to state that we propose to stand by the standards as established and as published.

There have been 150 channels built by the two major manufacturers here in Hollywood based on the performance given in the slides presented here today; and as far as I know, Loren, you have the only machine that does not work. So I think that rather than move the standards, perhaps you should fix your machine.

Mr. Ryder: I wish to make a point clear for the record; and that is, if the Committee of the Research Council have made up their minds before they hear an honest debate of this discussion, I don't think it's worth while to follow the recommendation of the Research Council. I don't believe that it is on that basis.

Mr. Mueller: I have recently discussed this with the other members of our committee, of which you are a member, and we see no reason for changing our opinions which were based on a study of more than two years.

L. T. Goldsmith: As Chairman of the Sound Committee of the Society, I wish to reconfirm that our Subcommittee on Magnetic Recording, under the chairmanship of Glenn Dimmick, had given wide study to all the proposed standards on magnetic sound track for over three years before they were published in the July issue of the Journal. Any comments received during the 90-day trial publication period are welcome and will be carefully studied by the Subcommittee. I would like to point out, however, that in the interest of avoiding industry chaos it is to the best interests of both the users and manufacturers of magnetic-recording equipment that standards which are used and approved by the great majority be adopted as rapidly as possible.

Added note by Mr. Ryder: Although it was not discussed at the meeting, the data collected at Paramount have been questioned on the basis that some of the measurements involve a larger-than-normal space between the drum and the record-reproduce head. We have curves to show that very bad effects can be produced by improper adjustment and tension of the head, especially under such conditions. The data presented and the curves shown in the paper are for the conditions where these effects would not exist and further, the curves as presented, and as shown by the graphs, tie together with measurements made with heads located as recommended by the manufacturers.

New Principle for Electronic Volume Compression

By HAROLD E. HAYNES

The principle described is a radical departure from those heretofore used in compressors. The features of this compressor are extremely low thump, very fast action (if desired), low distortion and freedom from the need for special circuit components or selected tubes. Fundamental circuits are discussed, and performance obtained with a complete compressor embodying the system is presented.

A VOLUME COMPRESSOR is an automatically actuated variable-gain amplifier, used for reducing the dynamic range of program material. The timing characteristics of the voltage derived from the signal for actuating the variable-gain amplifier are customarily such as to provide a very rapid gain reduction whenever the signal level rises abruptly, but to increase gain relatively slowly when the signal level drops. Very short acting times, less than one millisecond, are often used in order to minimize unwanted initial peak amplitudes on sounds having sudden large increases in envelope amplitude, such as certain spoken syllables.[1] If a change of gain is accompanied by a shift in d-c axis of the wave, a spurious aperiodic signal, commonly called "thump," will be produced. The d-c component of this shift will, of course, be filtered out by the low-frequency cutoff characteristic of the system; nevertheless, to the extent that the gain-reducing action can be considered instantaneous, this shift is a step-function and contains energy at all frequencies. The more rapid the attack and the better the low-frequency response of the system, the more objectionable will be the thump.

Presented on October 18, 1951, at the Society's Convention at Hollywood, Calif., by Kurt Singer for the author, Harold E. Haynes, Radio Corporation of America, RCA Victor Division, Bldg. 10-4, Camden 2, N.J.

Background

Brief mention of a few commonly used methods of varying gain will serve to point out their shortcomings as far as balance, or tendency to produce thump, is concerned. The most common type of compressor employs as a variable-gain device some nonlinear electrical element, an element in which the two electrical quantities employed as input and output are related by a curved characteristic. This type of element is utilized in such a way that the slope of the characteristic at the

operating point determines the gain of the circuit in which it is connected (which in general may be either greater or less than unity). Variations in gain are produced by superimposing upon the input signal an adjustable control signal, the amplitude of which determines the operating point. Examples of this type of variable-gain device are nonlinear semiconductors, such as Thyrite, and vacuum tubes as usually used in compressors and limiters.

In the latter class is the familiar "variable mu" or "exponential" pentode, in which various points on a curve of transconductance vs. grid voltage are selected by adding a control voltage to the signal in the grid circuit. It is clear that in this case, as with all others in which the control effect is merely a bias superimposed upon the signal, there will inevitably be an output component produced by a change in gain, and hence a thump.

There are other vacuum-tube variable-gain circuits in which the controlling voltage is not superimposed upon the signal. One example is the "loading-tube" circuit, in which the plate impedance of a tube is shunted across a relatively high-impedance signal source, and the value of this impedance is changed by varying the grid voltage. Here a family of curves of plate current vs. plate voltage exists, their slopes varying as a function of grid voltage. Unfortunately, however, changing from one curve to another causes a change in plate current, so that the same fundamental problem presents itself, as before. A generalization may be made to the effect that a change in any tube characteristic causes a change in plate current; hence, circuits of this class also suffer to a greater or lesser extent from an inherent tendency to thump.

The obvious and almost universal remedy is the use of push-pull circuits, in which signal is applied to the two variable-gain elements out of phase, while gain-control voltages are applied in phase. Recombining the outputs in push-pull fashion then makes the signal components in phase and the gain-control components out of phase, so that they tend to cancel. A great reduction in thump is thereby obtained, but it is apparent that in order for perfect cancellation to occur under all conditions the characteristic curves of the two elements must be identical at every point in their operating ranges. An estimate of the degree of similarity required if the thump level is to be negligibly low may be made on the basis of the following arbitrary but not ununreasonable assumptions: (1) that a change of gain between any two values within a range of at least 10 db should produce thump of the order of 40 db below signal level; and (2) that signal level is limited to 5% modulation of plate current by considerations of nonlinear distortion. These values lead to the conclusion that the plate currents must be equal (or differ by a constant amount) within something of the order of 0.05% throughout the operating range. Obtaining and maintaining the degree of similarity of characteristics necessary for such high-quality performance, though sometimes adequately accomplished, is expensive and time-consuming, and it frequently entails special selection and aging of tubes, plus frequent checking of those in service.

Principles of the New System

A means of varying gain by employing vacuum tubes, but one which is not based upon nonlinear characteristics, was thus sought and an approach which proved fruitful is described. It is based upon the principle of keying a transmission device between gain values of zero and some fixed value, at a high frequency, and obtaining different effective-gain values by controlling the relative durations of "off" and "on" periods. Otherwise expressed, this means amplitude modulating the signal with a high-frequency rectangular wave or

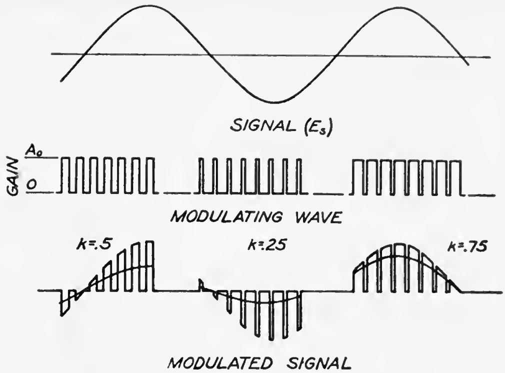


Fig. 1. Sinusoidal signal of frequency f_s modulated by a rectangular wave of frequency f_k.

series of rectangular pulses of varying duty factor. Of course, such a modulated signal contains high-frequency components not present in the original, but by proper choice of modulating frequency, these can readily be made inaudible and easily separable from the signal by filters.

The action is illustrated in Fig. 1. A sinusoidal signal of frequency f_s is shown modulated by a rectangular wave of frequency f_k, in which the duty factor is k. It is shown in Appendix A that the modulated wave contains the original signal multiplied by the factor k, plus an infinite number of modulation products of frequencies $nf_k \pm f_s$. It follows that if the maximum signal frequency component to be accommodated is, for example, 15 kc, the lowest sideband will be $f_k - 15$ kc. This sideband should be substantially higher than the maximum signal frequency, to facilitate removal of the sidebands. (It is pointed out later that the keying pulses should be as nearly rectangular as possible; hence, it is desirable to use the lowest permissible keying frequency, in order to minimize circuit difficulties.)

With the unwanted components of the modulated wave filtered out, there remains only the desired signal multiplied by k; hence, if the value of k can be varied in accordance with an appropriate control voltage, compression involving only linear electrical elements will have been accomplished.

Since the keying frequency must be at least 30 kc, a vacuum-tube circuit appears to be the only promising type of keying device. Hence, the same objection that was raised previously to tube circuits may at first seem valid, namely that a d-c component of plate current, which will change with changes in gain, will still be required. The important distinction here is that the tube will need to operate only *at one mean value of plate current* (corresponding to "on"), and *at cutoff* (corresponding to "off"). Thus, any two tubes can be used in push-pull, and substantially perfect balance can be obtained at their single operating points. They can, and should be, linear devices, and as such will permit relatively large signal amplitudes without objectionable distortion. Furthermore, their linearity may be enhanced by means of negative feedback, an expedient which would tend to nullify the gain-changing properties of conventional circuits.

Circuit Methods

Figure 2 shows the basic circuit of such a keyed amplifier. Two cathode followers are connected in push-pull, with positive keying pulses introduced in the cathode circuit. Pulse amplitude is sufficient to cut off plate current com-

pletely even when peak signal amplitude occurs. Additional positive bias voltages, E_{c1} and E_{c2}, permit desirable operating points to be selected, one of them being adjustable to permit balancing.

It is apparent that the keying pulses must have negligible rise and fall times, in order that the tubes will not be operating at points on their characteristic other than the desired one during an appreciable fraction of the time. This means that a minimum of capacitance loading should be permitted at any point in the pulse circuit. Therefore, resistors R_3 and R_4 are inserted to isolate the output transformer from the pulse circuit. Unwanted modulation products are removed by a simple low-pass filter following the out-put transformer.

An essential adjunct to the keyed amplifier, when used in a compressor, is a source of pulses of controllable duration and of approximately constant frequency, having the requisite relation between duration and control voltage. Appendix B shows that in a compressor deriving control voltage from output, as is customary, and having a slope of $\frac{1}{2}$ on a decibel basis (2:1 compression), numerical gain should be inversely proportional to control voltage; hence, a pulse generator was developed in which the "on" (negative) pulse width closely approximates this relation. Figure 3 shows the basic circuit of the pulse generator. A 45-kc square wave, generated by a multivibrator, is differentiated by C_1 and R_5, to produce a series of alternate positive-voltage and negative-voltage pulses of very short duration. The negative pulses cause capacitor C_2, which is also connected to the grid of sharp cutoff pentode V_3, to be charged negatively once for each cycle, through diode V_2. C_2 discharges toward zero through R_6, which is connected to the source of control voltage, the latter being variable from zero to a relatively large positive value. Thus, the plate current of V_3 is cut off for a portion of each interval between pulses which becomes smaller as the value of the control voltage is increased. It is these periods of cutoff which eventually become "on" pulses for the keyed amplifier, their duration relative to the pulse period being the factor k. The time constant of C_2 and R_6 is made about equal to the pulse spacing (22 μsec), and the potential to which C_2 is charged by the negative pulses is about ten times the cutoff grid voltages of V_3; hence, V_3 draws no plate current unless the control voltage has a substantial positive value. This means that the significant part of the discharge curve of C_2 is reasonably linear, and it can be shown that this causes the duration of the cutoff period, and hence the value of k, to be nearly inversely proportional to the control voltage, as desired. The rapidity with which the value of k can be changed, and hence the speed of action of the compressor, in practice is limited only by the properties of the circuit by which gain-controlling voltage is derived.

The plate-current pulses of V_3, which are roughly rectangular because of its sharp cutoff characteristic, produce voltage pulses which are further shaped by subsequent amplifier and limiter stages so as to have very short rise and fall times, and applied to the amplifier circuit of Fig. 2.

These two basic circuits, with the addition of conventional means of deriving control voltage proportional to compressed output, and having the desired timing characteristics, constitute a complete compressor. Since this type of control circuit is well known, and for the present application need be little different from those for other compressors, this subject will not be discussed further.

Performance

A complete compressor based upon these circuits has been built and is

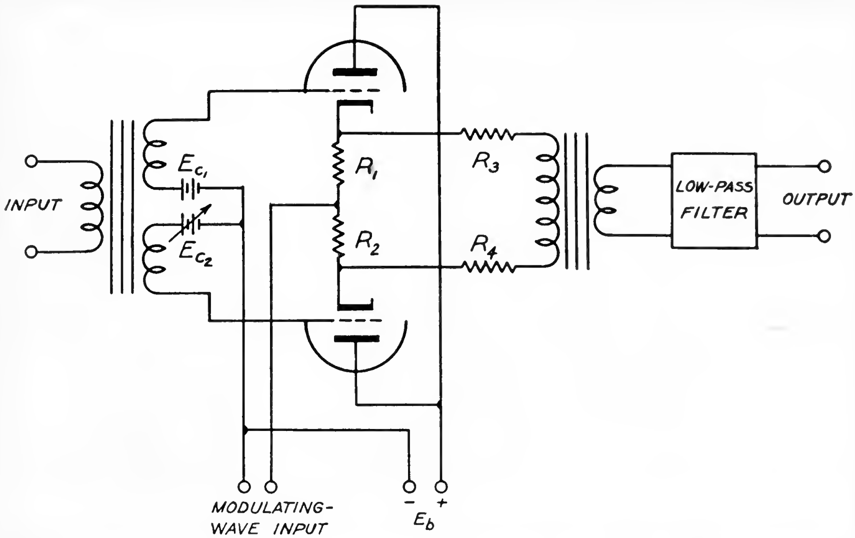


Fig. 2. Basic circuit of vacuum-tube keyed amplifier.

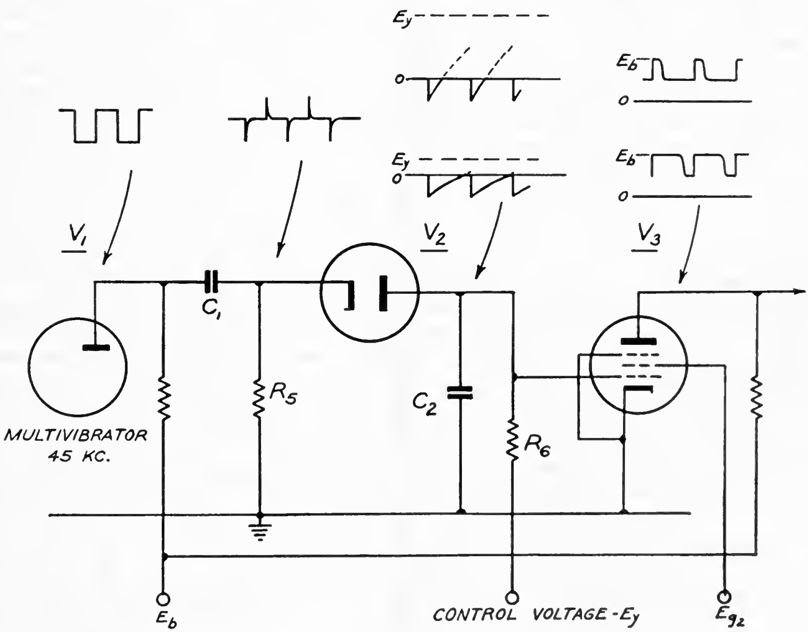


Fig. 3. Basic circuit of pulse generator.

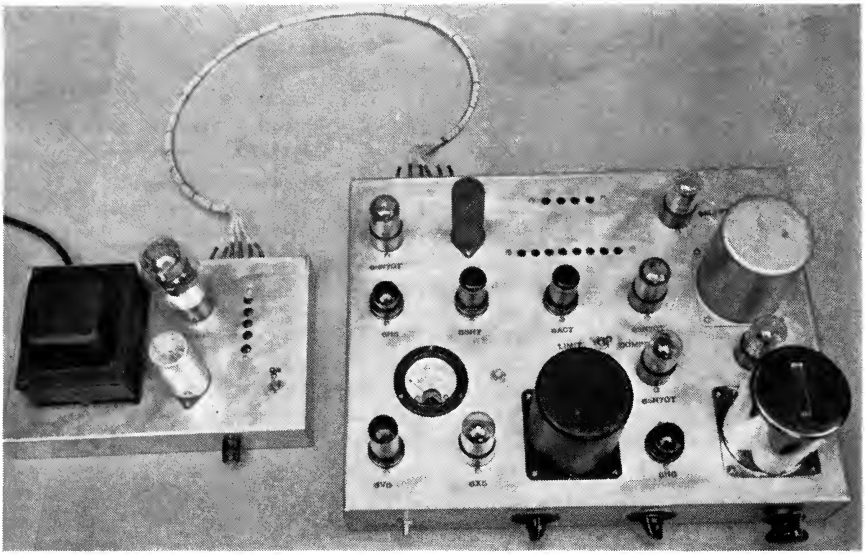


Fig. 4. Complete compressor based on the circuits shown in Figs. 2 and 3.

illustrated in Fig. 4. Its operating characteristics were made to conform to those of existing compressors so that its performance could be easily evaluated. Although this model is somewhat more complex than the simplest compressors, no special tubes or other special components are used. It affords a useful gain-reduction range of more than 15 db. Performance, especially with regard to thump, is excellent, both with respect to the degree of balance obtainable and to the long-time stability of this balance.

Two chief methods have been used for observing and measuring the effects of unbalance in compressors. One which is typical of actual operating conditions, described by Maxwell,[2] consists of abruptly raising the level of a relatively high frequency sine-wave input signal to the compressor and observing on an oscilloscope the transient appearing in the output. Although it depicts the thump phenomenon very graphically, this test is open to the objection that it takes into account balance conditions at only two specific points in the gain-reduction range. Also, in a well-balanced compressor the transient amplitude is too small to be conveniently observable. A second method, often built into compressors as a balance check, measures cross modulation between the gain-control circuit and the signal circuit by applying a sinusoidal test voltage in the gain-controlling circuit. A single test of this kind includes the effects of unbalance at all points in the gain range swept, and if the test conditions are suitable it affords a good overall evaluation of balance.

Measurements of both types have been made on the pulse-modulation compressor. In the first type, a 250-cycle low-pass filter was used, following the compressor, to reduce the carrier amplitude and thereby make the transient more easily seen. For a 10-db increase in input (5-db gain reduction), signal-to-thump ratios of 50 to 60 db were obtained.

The cross-modulation method is felt to be preferable for specifying un-

balance, because it does detect unbalance at all points in the range used. A figure of merit called "signal-to-unbalance ratio" is proposed to describe the performance of a compressor when tested in this manner. It is expressed in decibels and is defined as follows: Signal level is the maximum output level, with 10 db of gain reduction, at which some satisfactorily low value of total harmonic distortion of a 1000-cycle signal is produced. In the present case, this value is taken as 0.5%. Unbalance level is the output produced, in the absence of signal, by a 60-cycle control voltage which varies the gain reduction throughout the range of 0 to 10 db.

Using this cross-modulation test method, excellent signal-to-unbalance ratios have been obtained, along with freedom from the need for special tube selection and from the necessity for frequent rebalancing. Tests have shown that, except for the possible rejection of perhaps 10% of samples, tubes selected at random for the variable-gain stage (6SN7GT) will all produce optimum signal-to-unbalance ratios of 55 db or more. Operation over periods of a few hundred hours has indicated that the balance does not deteriorate more than 10 db during this length of time, and that the original figure can be readily regained by rebalancing. Although unregulated heater and plate supplies were used, line-voltage variations of 10% also increase the unbalance only about 10 db.

By adoption of pulse-modulation techniques, it has thus been possible to construct a compressor whose performance regarding thump is equal or superior to that of any now used in the most exacting applications, without the need for specially selected tubes or other components. Its moderate added complexity is felt to be of secondary importance in the light of its very significant advantages.

APPENDIX A

The modulating wave of Fig. 1 can be represented by the expression[3]

$$a = A_O\left[k + \frac{2}{\pi}\left(\sin k\pi \cos \omega_k t + \frac{1}{2} \sin 2k\pi \cos 2\omega_k t + \frac{1}{3} \sin 3k\pi \cos 3\omega_k t \ldots\ldots + \frac{1}{n} \sin nk\pi \cos n\omega_k t\right)\right], \tag{1}$$

where:

a = instantaneous value of gain,
A_O = gain value during "on" periods,
ω_k = $2\pi f_k$ = fundamental angular frequency of modulating wave,
k = ratio of pulse width to period of modulating wave.

The signal wave is:

$$e_s = E_s \sin \omega_s t. \tag{2}$$

An expression for the modulated wave is obtained by multiplying (2) by (1):

$$ae_s = A_O E_s\left[k \sin \omega_s t + \frac{2}{\pi}\left(\sin \omega_s t \sin k\pi \cos \omega_k t + \frac{1}{2} \sin \omega_s t \sin 2k\pi \cos 2\omega_k t \ldots\ldots + \frac{1}{n} \sin \omega_s t \sin nk\pi \cos n\omega_k t\right)\right]. \tag{3}$$

The first term, $kA_O E_s$, is the desired output. Each of the other terms is the product of a sine term, a cosine term and a constant, depending upon the value of k. The general term:

$$\frac{1}{n} \sin \omega_s t \sin nk\pi \cos n\omega_k t \tag{4}$$

can be rewritten as:

$$\frac{1}{n} \sin nk\pi\left[\frac{1}{2} \sin (\omega_s t - n\omega_k t) + \frac{1}{2} \sin (\omega_s t + n\omega_k t)\right]. \tag{5}$$

Since $\omega_k > \omega_s$, this is better rewritten as:

$$\frac{1}{2n} \sin nk\pi \left[- \sin (n\omega_k t - \omega_s t) + \sin (n\omega_k t + \omega_s t)\right]. \tag{6}$$

APPENDIX B

If the gain-vs.-input relation in the compression range is to be linear when expressed in decibels,

$$Db_O = kDb_i + c, \tag{7}$$

where:

Db_O = output level in db,
Db_i = input level in db,
k = slope of compression curve,
c = a constant.

On a numerical basis,

$$20 \log E_O = 20\, k \log E_i + e, \text{ or } \log E_O = k \log E_i + c', \tag{8}$$

where:

E_O = output voltage,
E_i = input voltage,
c' = a constant.

If the gain-controlling voltage is derived from and is proportional to compressor output, it is of interest to express voltage gain as a function of output:

$$\frac{E_O}{E_i} = f(E_O) \tag{9}$$

and determine the nature of the function f.

From (8),

$$E_O = c'E_i^k, \text{ or } E_i = \left(\frac{E_O}{c'}\right)^{\frac{1}{k}}. \tag{10}$$

Thus:

$$f(E_O) = \frac{E_O}{E_i} = \frac{E_O}{\left(\frac{E_O}{c'}\right)^{\frac{1}{k}}}$$

$$= c''E_O^{\left(1-\frac{1}{k}\right)}. \tag{11}$$

For 2:1 compression, $k = \frac{1}{2}$, therefore:

$$f(E_O) = c''E_O^{\left(1-\frac{1}{1/2}\right)}$$

$$= \frac{c''}{E_O}. \tag{12}$$

References

1. R. O. Drew and E. W. Kellogg, "Starting characteristic of speech sounds," *Jour. SMPE, 34:* 43–58, Jan. 1940.
2. Donald E. Maxwell, "Dynamic performance of peak-limiting amplifiers," *Proc. IRE, 35:* 1349–1356, Nov. 1947.
3. F. E. Terman, *Radio Engineer's Handbook*, 1st ed., McGraw-Hill, New York, 1943, pp. 22, 23

Prints From 16mm Originals

By R. L. SUTTON, K. B. CURTIS and LLOYD THOMPSON

The introduction of reversal film — both black-and-white and color — made 16mm photography very acceptable for commercial use. Release prints in quantity were a problem. New printing equipment had to be designed and built, and new materials and techniques had to be improved. This paper will describe the methods used by The Calvin Company for producing high-quality release prints in quantity at the present time.

THE INTRODUCTION of black-and-white reversal film and, later, the introduction of color reversal film made 16mm photography practical. Through the use of these 16mm reversal materials, the field of motion picture photography was extended to many potential producers. Originally, it was thought that 16mm film would be for amateur use only. It was but a short time, however, until it was also being used for professional purposes. The amateur motion picture field has continued to grow and change, and today we find wide professional use of 16mm materials while the majority of amateur use is 8mm film. With professional use of 16mm materials, duplicate prints naturally were desired. This involved extensive work in printer design and also in photographic research to obtain better materials and methods for making duplicate prints from originals, both in black-and-white and in color.

Presented on October 17, 1951, at the Society's Convention at Hollywood, Calif., by R. L. Sutton, K. B. Curtis and Lloyd Thompson, The Calvin Company, 1105 Truman Road, Kansas City 6, Mo.

Much of the research and design of printers has been accomplished by the pioneers of 16mm film because they were intimately aware of the changes resulting from the growth and improvements in this field. Two important factors resulting from the improvement of 16mm materials vitally affected the design of printers for 16mm films: (1) the changes made in the physical characteristics of the original film; and (2) the fact that more and more printing exposure light has been necessary to print the new products as they were developed. Generally speaking, a printer designed to print one type of 16mm film often was obsolete almost overnight when another type of film showing new, different and improved characteristics was introduced; therefore, frequent changes in printer design were necessary in the early days of the industry. The problem was not so much in using the newer materials as in the difficulties of printing films as they aged. The problem of shrinkage and the effect of aging on film splices was often pronounced in older originals and it was difficult to find a printer

that would accommodate both normal and shrunken or aged originals. With the introduction of newer materials, the necessity for increasing the exposure light often demanded changes in printer design.

In setting up specifications for a printer, or a system of printing, it would appear that the problem would be simple. The problem is to make sound prints, in either black-and-white or color, that have consistently good quality at a speed that is economically feasible when using 16mm reversal originals. However, to accomplish these things, we believe a printer, or system of printing, should have the following characteristics:

1. The printer must give good contact and produce prints having good steadiness.

2. Sufficient uniform illumination must be available to print on such Eastman stock film as Type 5504, reversal duplicating; Type 7302, fine-grain release positive stock; Type 5365, black-and-white fine-grain duplicating positive; and Type 5265, color stock. If possible, additional illumination should be available to provide for future needs.

3. The printer must handle originals so that they are not scratched or damaged, even though large numbers of prints are made from the same original.

4. The printer must be able to make satisfactory prints from originals with normal and abnormal shrinkages. Our definition of these would be a shrinkage of from 0.01 to 1.5%.

5. A system of light changes for density corrections in the original must be provided, and this should be as foolproof as possible.

6. A minimum of maintenance should be required on the machine, and this must be done with a minimum of expense.

7. The printer, or system of printing, should provide for optical effects, in each individual print, as well as straight printing.

8. Provisions should be made for adding a filter pack to the light system. This should be far enough away from the light source so that the heat does not damage it over a long period of time.

9. Future requirements should be anticipated, insofar as possible, for such things as the color correction of individual scenes, when such methods become practical.

10. Means should be provided for an accurate measurement of illumination, both as to quantity and color quality of the printing light.

11. The power supply should be kept simple and, if possible, should operate directly from standard 60-cycle a-c current.

12. In designing, we feel that wherever possible standard parts, available on the open market, should be used to keep the original cost down, but more important, to allow for repairs with a minimum of trouble and expense.

13. The operation of all printers should be as simple and as automatic as possible so as to require a minimum of training for new operators, and thus reduce errors.

14. The printer should accommodate a minimum original print footage of 1200 ft and, if possible, it should handle 2000-ft rolls of originals and raw stock.

15. The take-up mechanism should handle both short and long lengths of film without trouble.

16. If the design of the printer is such that there is any tendency for the printing aperture to collect dirt, lint or hairs, an air blast should be provided to keep it clean at all times.

17. It would be highly desirable for the light-change cuing device to be standard. A notchless system is preferable. However, inasmuch as there is no standard for this, each laboratory has set its own standard as to where film should be notched. While it seems to be impossible to standardize the number of frames between the scene changes and the notch, it is in most

cases possible to standardize the type of notch. We have chosen the Bell & Howell narrow notcher for this purpose.

18. In making black-and-white reversal prints from black-and-white or color originals, reversal color prints from color originals, dupe negatives from either black-and-white or color originals, it is necessary that the light change between each step be greater than for printing positives from original negatives, as is customarily done in 35mm film. The design of a light-change system must take this into consideration.

19. The claw which moves the original and raw stock in a step printer should be exactly opposite the picture aperture in order that the framelines in the print be as nearly like those in the original as possible.

No doubt other specifications could be added and probably will be, as techniques and materials change.

We originally tried to solve our first printer problem by converting a Bell & Howell projector head into a printer. In many ways this did a good job, but it was not too long before it was obsolete. Several different printers were built and tried, but each had its limitations. We finally reached the conclusion that, for a system of printing suitable for our use, it would be necessary to have three types of printers:

1. A step-type picture printer.
2. A continuous-type picture printer.
3. One or more types of sound printers to add sound to the picture prints, made on the step- and continuous-type printers.

The Step-Type Printer

First, let us describe the step-type picture printer and see how it meets the specifications. By looking at Fig. 1, you will immediately recognize that a number of standard parts have been used to build this printer. Some of these parts, such as gears, which cannot be seen in Fig. 1, are also standard. An inspection of the printing gate will show that the raw stock and the original film are handled separately so that tension is applied to each of the films. They are also edge-guided, separately. This was done in order to assure a steady print and to eliminate side weave. The printing gate is curved in order to remove the curl in the original film, so that good contact could be made with the raw stock. By using this method to flatten the original film for good contact, it has been possible to relieve the printing gate at all points where the original film would touch metal. Experience has shown that the only way to keep from scratching film is not to let it drag on anything, regardless of how highly polished it may be. Such a surface will eventually cause trouble.

Certain types of duplicating film, especially Kodachrome, have a tendency to curl or cup at low relative humidities, which means that good contact is not always possible in the middle of the picture. This tendency can be minimized greatly by maintaining the relative humidity in the printing room at about 50%. To eliminate this difficulty, a special pressure shoe was designed to hold the raw stock against the original in the center of the film. Thus, the problem of contact and steadiness was solved in this particular printer. This type of gate is very easy on the original film. Damaged sprocket holes, or other defects in the original, may cause it to lose a loop, but the original is not damaged. Examination of the printing gate will show that the pulldown claw is exactly opposite the picture frame, thus making it possible to keep the frameline as nearly like the original as possible. Productions photographed with several different cameras having widely different framelines will cause trouble. About the only way to minimize such trouble is to use an especially wide frameline in the printer at the time prints are made from such originals.

In order to secure optical effects in

Fig. 1. The step picture printer with light-change board.

the prints, The Calvin Company has for a number of years printed from A and B rolls in combination with A and B rolls of optical-effects mattes (Fig. 2). This means that our printers must be able to run the optical-effects mattes. This system has been described before,[1] and since most people are acquainted with such mattes only a few things need be said here. The success of the system depends upon the optical-effects mattes being projected onto the back of the original film as it is printed on raw stock. Such mattes cannot be run in contact with the original, as has been done in 35mm, for several reasons. Trying to run three pieces of film through one film gate causes a lot of trouble and in addition, any dirt, scratches or slight defect in the matte will be printed into the final print quite easily. By projecting these mattes and throwing them slightly out of focus, nearly all of these difficulties have been eliminated, and doing so completely avoids the trouble of trying to run three pieces of film through one gate at the same time.

A standard Bell & Howell silent projector with certain modifications was used as a matte runner, and as a light source for printing. In order to use a projector for this purpose it was necessary to disconnect the regular projector motor and use an external constant-speed motor to drive the ventilation fan, because the regular projector motor would not stand up under such long, hard service. It was also necessary to construct a special tube which would fit very close to the aperture of the projector in order to eliminate the majority of the stray light which escapes from the projector in the printing room. A method had to be provided for carry-

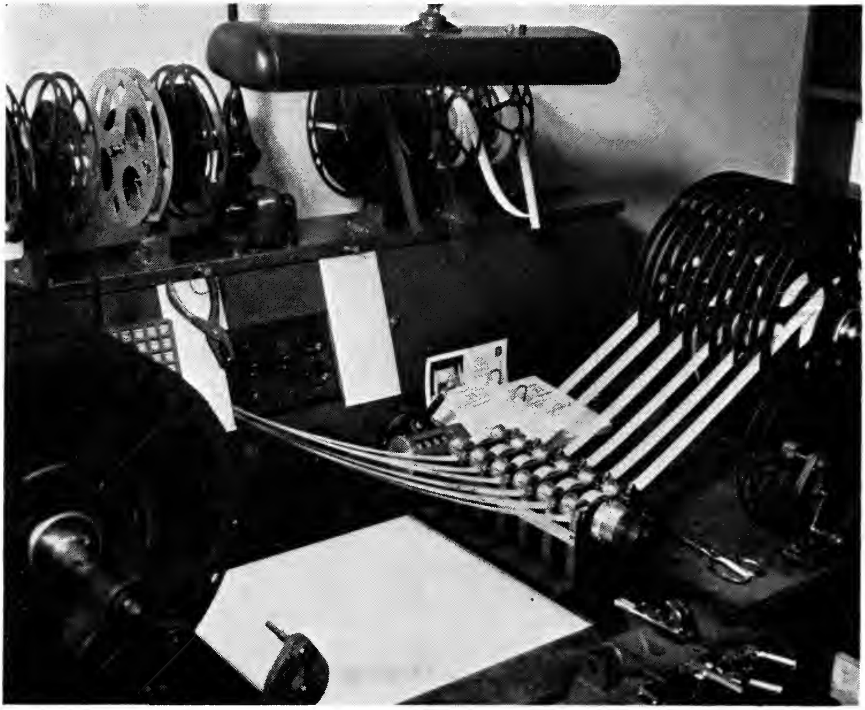


Fig. 2. Optical-effects and density mattes, A and B rolls, etc., are checked on this multiple synchronizing equipment.

ing the heat from the lamp out of the printing room and, in doing this, we have also trapped the stray light at the top of the lamphouse to prevent its entering the printing room. The optical system for projecting the effects mattes is a standard projection lens. We use the largest-aperture lens available for the focal length involved to gain efficient light transmission. The color-correction filters used in the filter pack are placed in the printer head of the mechanism as far away from the light source as possible, and there has been practically no damage caused by heat from the lamp affecting these filters. They are stable over a period of many months.

A special device has been made which can be locked over the printing aperture to hold a photoelectric cell for measuring illumination. This photoelectric cell is connected to a galvanometer. Furthermore, the device is fitted with a multiple slide carrier which holds color filters as well as neutral density filters. When the illumination level is to be measured the neutral density position on the carrier is used. The other three positions are used for checking the quality of the printing light for color printing and for matching individual printers. This device has previously been described by P. S. Aex.[2] We have added the fourth slide with the neutral density filter for checking the quantity of light, and have found this to be a useful addition.

Take-ups on all machines handling film have always been a problem. At the time our present printers were built we were more satisfied with the

constant tension cloth belt type of take-up, as used on several projectors, than any other we had ever used. In general, these have been very satisfactory. However, torque motors have been used on a number of take-up mechanisms in the last few years, and new printers are now being built with torque motors as take-ups. Results indicate that these will be even more satisfactory.

Light-Change Devices

Light changes are made in this printer by a resistance type of board (Fig. 1). We realize that, theoretically, a resistance board should not be used in making density correction in color prints, but we have both types of light-change devices in our laboratory, as will be described later. Experience has shown time and time again on tests we have conducted that, for all practical purposes, there is no difference between the changes made with a resistance board and those made with a neutral density type of correction. For that reason, we have continued to use this type of system on the step printers. A change of illumination, or a change of materials or processing in the future may make this statement void.

Originally, drop-type light boards were used with all the difficulties encountered with such boards. When it was necessary to replace these we thought it desirable to make a number of changes, and so another type of light board was built. The idea is not new; but, on the other hand, we do not believe that these boards are generally available on the open market. A piece of 35mm positive film is punched and used in the mechanism to actuate the light changes (Fig. 3). Since there is not enough room on a piece of 35mm film to make enough punches to allow for 18 different light changes — which is the standard we use — it was necessary that we make a punching machine that would punch these light changes in code. By looking at one of these pieces of film it can be seen that the first six light changes are made by simply punching a hole in the proper place for numbers one to six, but number seven light change is one and two, number eight is one and three, etc. By using this code system, it has been possible to get all the light changes on the strip of 35mm film. In addition, we have room left over for several holes which can be used to add automatically the corrective filters to the light beam at the same time the light changes are being made, if such changes are desirable. Such a system of making color correction is not in general use in the field as yet, although most laboratories have some method of doing this if the occasion demands it. As color processing becomes more refined and as other new materials are added for duplicating purposes, we feel the time will come when color corrections will be desirable and probably necessary.

Such a light board has a number of advantages over the conventional drop-type board. There is no limit to the number of light changes that can be made in one reel of film. In other words, a hundred changes can be placed in one 400-ft film if necessary. This system is highly desirable when printing long lengths of film. Such a system also means that once the film has been correctly cued, it is impossible for the operator to set up the board incorrectly. Furthermore, it eliminates hours of wasted setup time. With this system it is only necessary to thread the strip of film into the light-change mechanism, turn it up to a point where a signal light comes on, showing that it is in proper position to print, and then proceed to print. This cuing strip is kept with the original film at all times and, in the future, when a print is wanted, all that is necessary to set up the board is to thread in the strip and proceed to print. Built into the light board is a voltage regulator which automatically keeps the voltage level constant. A variac is also included in the circuit so that small

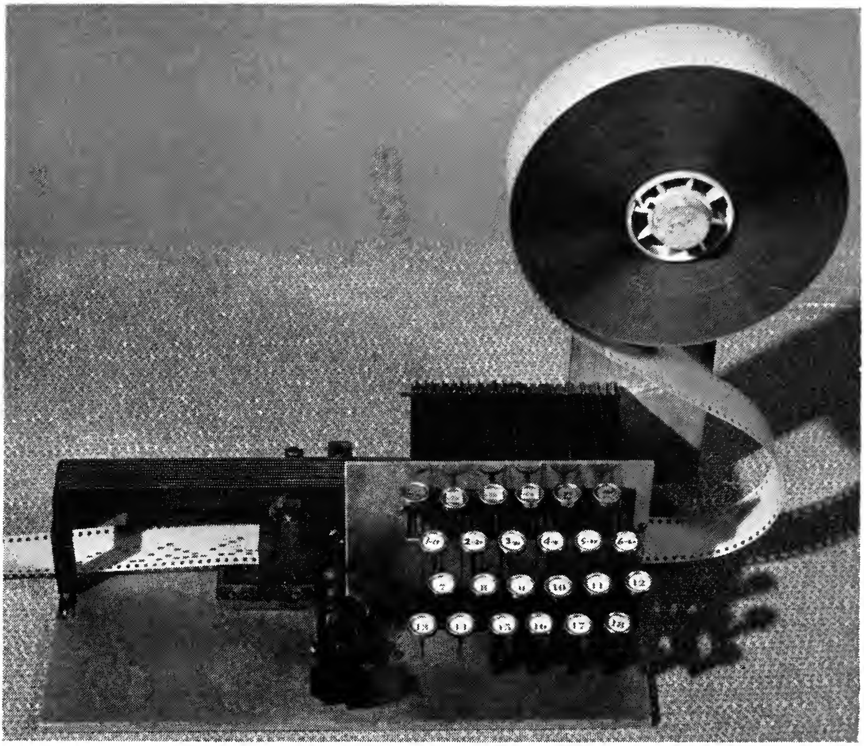


Fig. 3. This punch is for making the light-change cue strip and also color-correction changes. The upper row of keys is for correction.

variations in normal light can be made in order to correct small changes in the filter pack, etc. By measuring this normal light with the photoelectric cell circuit, previously described, it is possible to keep the printing normal quite constant.

Built into the printer head is an air-blast mechanism which constantly blows against the printing aperture, thus keeping it free of dirt and lint which might otherwise accumulate.

This step printer, we believe, meets the specifications we outlined previously and can be used for making Kodachrome prints, reversal prints, dupe negatives and, with the proper aperture, black-and-white positive prints. Such a printer is necessary for a small quantity of prints from one original and for special purposes, such as the making of dupe negatives.

The Multimatic Printer

There is, however, another problem that we do not feel the step printer answers as it should. This is the problem of large-quantity print orders from the same original. For this purpose we have designed a continuous-type printer which is known as the *multimatic* printer (Fig. 4). This is a three-headed printer which was originally designed for making color sound prints with optical effects and light changes, automatically. The machine runs in both directions and once it is threaded with the proper optical-effects mattes and density-change mattes

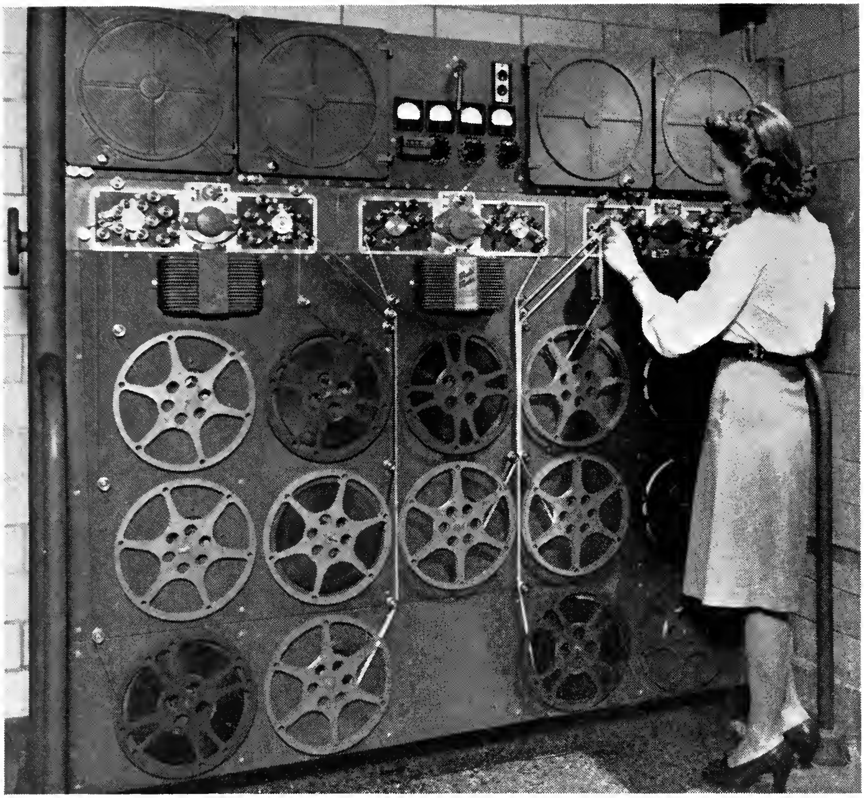


Fig. 4. The Multimatic printer threaded for making sound Kodachrome prints with optical effects and light changes. The optical-effects and density mattes are on separate rolls on this setup.

it is not unthreaded again until the prints are finished or the originals are taken off for cleaning. The operator simply stops the machine at the end of each print, threads on more raw stock, and makes another print going back in the opposite direction. This way, there is never any rewinding of originals. In addition, the machine has the advantage of being able to use odd lengths of film which are a problem in Kodachrome printing. The printer may be backed up at any point, utilizing odd lengths of raw stock. Once these have been returned from processing they can be cut in at the proper point and spliced together, thus using raw stock with a minimum of waste.

This machine has been built to handle 1200-ft rolls of original and raw stock, and runs at 72 ft/min in either direction. Light-change boards for such a machine would complicate the job and probably give a considerable amount of trouble. For this reason, we made a special density matte containing the light changes which are run along with the optical-effects mattes, thus producing the desired effects and light changes in the print. These density mattes are made on a Bell & Howell Model J printer which has been remodeled for

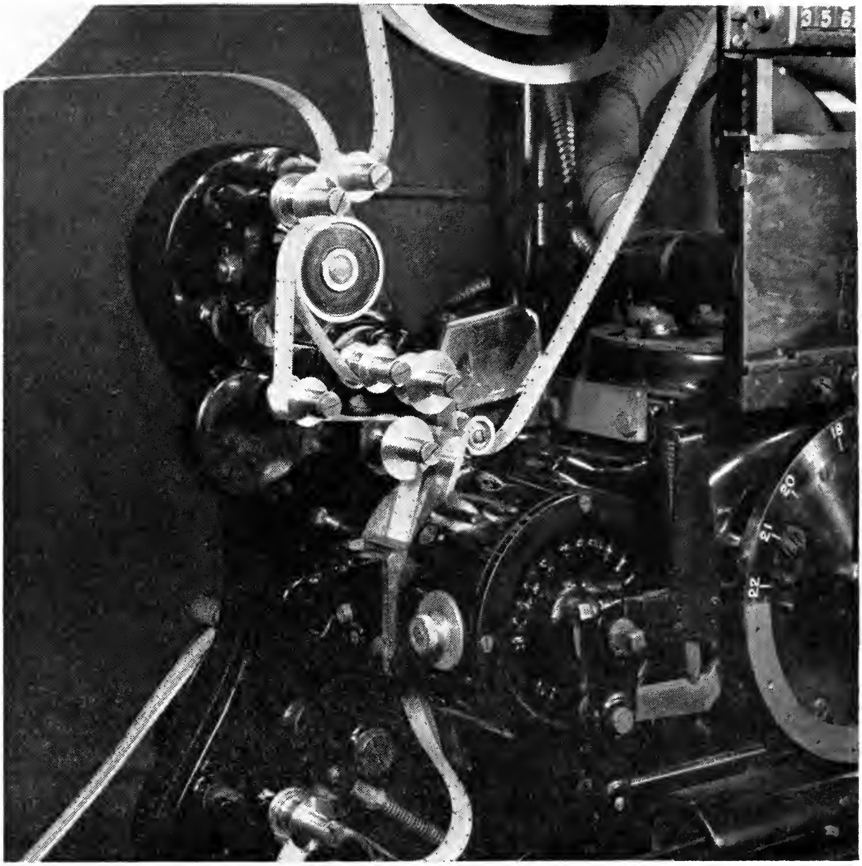


Fig. 5. Modified Bell & Howell Model J printer for making density mattes. The cue film is threaded around the gate.

this work (Fig. 5). Such a matte system, of course, does not change the color temperature of the lamp. As we have said previously, prints made by this method do not show any particular difference from those made with the resistance type of board on Kodachrome film as we know the process today. The printing on this machine is done on a 40-tooth sprocket which has been designed to accommodate film shrinkages up to 1.5%. Contact is maintained with a rubber roller at the printing aperture. Here again the problem of curl in Kodachrome Duplicating Film made it necessary to provide this rubber roller for consistent operation. The shoe type of contact which is generally used on continuous printers was too critical in adjustment and too hard to keep in adjustment to be satisfactory.

Printing is done by contact on the 40-tooth sprocket with the mattes printed optically from the opposite side of the sprocket below. The filter pack is placed between the objective lens and the printing aperture. Beneath the matte aperture, and enclosed in the lamphouse, is a right-angle prism which turns the light up from a horizontal

source. Thus, the lamp occupies a normal upright position. Beside the objective lens, there are three condensing lenses. As in the step printer, the original film does not touch metal at any point, so the chance of scratching the original is at a minimum. Many scratches or cinch marks are caused in rewinding original material. Since the originals are not rewound between prints when they are made on this printer, the danger is largely eliminated. The printer was designed to make a large number of Kodachrome prints from a single original, so that second-generation prints would not have to be used as originals. We do not know how many prints can be made from one original on this machine, because we have never made a large enough number to find out. We have printed over 600 Kodachrome prints from one original, and from all appearances a good many hundreds more could be made from it. This does not, of course, mean that that many prints could be made from any original, because we frequently receive originals which are in bad shape before we ever start printing them. However, when the originals received for printing are in good shape and good splices have been made, we have had almost no trouble in making as many prints from them as any customer might want.

The *multimatic* printer is also suitable for making prints from dupe negatives and sound tracks. When a printer is used for this purpose only two heads are used — one picture head and the sound head. Of course, the optical-effects mattes are not used because both the optical effects and the light changes have been incorporated into the dupe negative. Nearly all black-and-white release prints are now made by using a dupe negative from original reversal black-and-white or color, and then printing on fine-grain positive. Black-and-white reversals are used on only a few special orders.

The third type of printer which we must use is the sound printer. Prints made on contact step printers have the sound added from a Maurer optical printer. Before the dimensional characteristics of sound-film base were stabilized, this type of printer was highly desirable as it would handle originals with various degrees of shrinkage. When the *multimatic* printers were built, provisions were made for printing the sound optically. However, tests at that time did not indicate any advantage would be gained by this method, and still other tests made over a period of years have confirmed this point. These tests were made in our own laboratory and in other laboratories, using the optical system of sound printing. Therefore, the sound on the *multimatic* is printed by contact.

An Optical-Effects Printer

At the present time, we are putting into operation a new machine which was designed to be used with the *multimatic* and step printers. This is known as the Curtis Automatic Effects Printer (Fig. 6). This machine is an optical-effects printer to be used for printing the optical-effects mattes. Up until the present time all these mattes have been edited and spliced to the picture by splicing together optical effects with black and clear film. Instead of making up a matte in this manner, we now punch both edges of the workprint with cue marks and the workprint is used to cue the optical-effects printer. The printer is then loaded with positive film, turned on, and it automatically prints the mattes with wipes, fades and dissolves, all in one piece of film. As soon as this film has been developed it is then ready for checking and printing. In addition to printing the optical effects onto this piece of film, we can add a density wherever necessary so that when we have a final matte for printing it will make both the optical effects and the light changes.

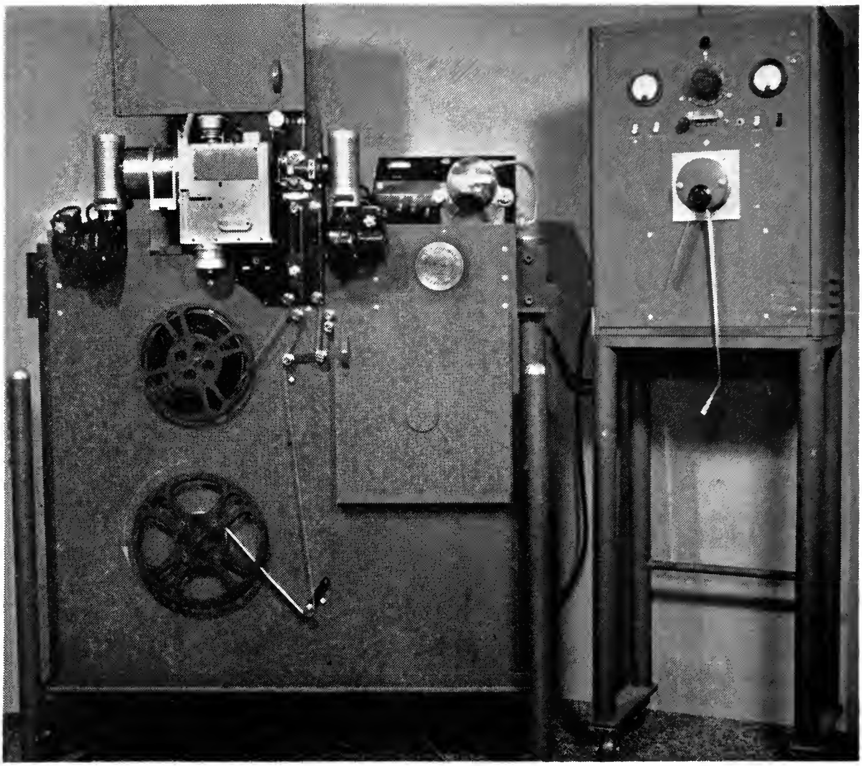


Fig. 6. Optical-effects—density-matte printer. The light-change board is threaded with a punched 35mm strip for selecting the proper printing exposure for the density matte. A second 35mm punched strip (hardly visible in photograph on right top of printer) is used as a selector for the proper optical effect.

How does the machine operate? Basically, it is built around a peculiar arrangement of movements that control the effects blades. Each effect, with the exception of the straight wipes, has a set of these movements which combine the four standard effects of that type through selective triggers into a single unit with only one set of movements. Since the straight cut is not considered an effect, the omission here of a set of movements is not another exception, even though the dowser, responsible for the straight cut, is also used as an integral part in every effect.

First among the parts involved in each set of movements is a planetary-gear type of clutch which is geared direct to the main driving shaft of the machine. Upon a given signal it is released for a single cycle at a rate proportional to the number of film frames involved in the effect being driven. In turn, an eccentric pin, geared to the clutch, drives a movement known as the Walschaert gear. The object of the Walschaert gear is to allow admission to a new source of driving power, emanating from a double-acting, rotary-type solenoid. This quickly reverses the effect back to its normal position or, if the reverse operation is involved, out of its normal position before or after the planetary-gear clutch

has released its cycle of motion, let us say, causing the effect to close. The solenoid, acting through the Walschaert gear, quickly opens the effect back to its original position. But, before the solenoid can work, the dowser chops off the light, holding its closed position until the next signal reverses the continuity of operation and opens it. Each set of movements is extremely versatile.

During the closed position of the dowser, or any other blade for that matter, no light can reach the film. Hence, the film will be transparent during this period following its development and will allow printing to be done through it. Therefore, the image of a closing blade actually opens a scene, while the image of an opening blade closes the scene. This commonly understood inversion is only one among many encountered in the machine. The opening and closing of each sequence is continuous throughout a film and is the means by which release printing can be done, subsequently, at first one gate and then another without the show of a splice. The dowser is the only automatic instrument in the machine that needs to be positioned before a run, and that is done in the course of preselection. All other effects hold a normal open position when not in use.

The mechanical movements just described entail considerable electrical equipment which includes a signaling system. Its manipulation throughout one run is made easy, however, by simply edge-notching the workprint for each effect and/or timing change as desired and by perforating two 35mm films as selector strips. Since two combination mattes (timing and effects) are required for each show, both edges of the workprint are notched as A and B, respectively, and two more selector strips perforated to match for the second run. The use of both edges of the workprint avoids making an extra cue film and retains the advantages of notching to an actual picture continuity.

Preselection is not relegated to any one department or person. It is an accumulative process, developed over the preparatory printing route. The signal originates with the workprint because, when edited, the splices between scenes represent the absolute, with reference to the desired effect, if any, penciled on the film in code. This eliminates the script from further use in finishing the picture. When the originals are being critically scanned for timing in the laboratory, the estimate of correction needed for each scene is recorded on a cue sheet in terms of light-change numbers for future use in punching the selector strips. The workprint is also included on the same gang synchronizer, and is marked for edge notches which coincide with the timing tabulations entered on the cue sheet. Actual notching, however, is done later when the workprint is returned to editing with the cue sheet. Here the effects and timing continuities are matched so that a single notch will accommodate both as often as possible. Also, the effects cues are tabulated on the same cue sheet which is then sent back to the laboratory where it is used in punching the selector strips. Finally, the strips are brought together with the workprint at the machine for the run.

To insure proper placement of the notches, two standard Bell & Howell notchers have been cut down and mounted side by side into a single unit (Fig. 7). The two blades, marked A and B, respectively, face one another across one film path with edge guides intact. In this path a single pilot pin is mounted between the blades to insure positive registration to the notch in relation to the sprocket holes. A graduated scale is mounted off to the left and points out where the splice between scenes shall be placed when notching for each type of effect. Furthermore, the scale translates the effects code, penciled on the film at the splices, into the particular selective station numbers con-

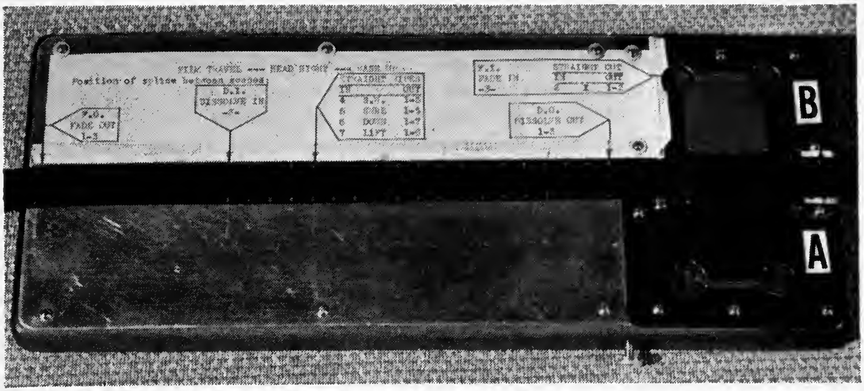


Fig. 7. Special punch for notching cue film, or workprint, for Curtis effects—density-matte printer.

cerned. Index buttons on the A and B edges of the notching block are manually pushed back and forth to remind the operator of the particular track (A or B) a scene or sequence is relegated to as the alternations proceed, otherwise the picture continuity of the workprint is obviously without this information. The location of timing notches depends only upon the marks penciled on the film in timing, which may be at the splice with certain opticals or apart within the scene proper. Because timing is included in each combination matte, there are no edge noches in the originals, which inadvertently serves to circumvent the lack of a notching standard as discussed previously.

In this respect, it is well to note that, while the entire process is really quite simple, there is a definite technique involved in both preselection and machine operation that readily lends itself to a minimum of schooling among the personnel taking part.

The size and arrangement of the perforations in both selector films provide room at each step for ten selective stations, positioning being equal to the spacing of the sprocket holes. This gives the workprint notch control over 20 selective stations. Of the ten timing stations only six are used to control a wide range of light changes, while of the ten effects stations only eight are at present in use, leaving an ideal situation for future development. Preselection is done in the laboratory, as previously stated, on a punching machine, the keyboard of which resembles a typewriter.

Timing is arrived at through coupled resistors in series with the lamp, selection for intensity being directed through a relay system interlocked with the various taps in the resistor. There are 18 different light-intensity levels available, each arrived at as a plus or minus relative of the ninth level, which is manually preset through a variac. Since timing requires a finer gradation of light, the lamp is located on the emulsion side of the raw stock which is separated from the constant-burning effects lamp, located on the base side. However, the effects light also requires accurate setting because of the fade effect which is a form of the photographic wedge. Both lamps converge their rays along the axis through separate optical systems onto the same gate, which is so constructed that it has an aperture on each side of the film. Since certain effects are made optically, such as the wipes, there is an objective lens on the effects

side which makes a camera of that part of the printer. This cameralike head has a dissolving shutter for the fades and a dowser for both the straight cuts and effects auxiliary. Beyond this head, large condensing lenses spread the light field for the effects. The timing system has only a small condenser lens, but there is a density filter pack included. Both lighting systems have separate voltage regulators, transformers for low-voltage lamps, manually controlled variacs, voltmeters and ammeters.

The machine is of the step type and its product will eliminate the separate light-change matte which was previously used on the multimatic printer.

Experience has shown that most of the optical effects wanted today are fades, dissolves, right and left wipes, and up-or-down curtain wipes. The printer has been built to provide these, automatically, on signal. Any special wipe can, of course, be cut into a printed matte if necessary. But, if this is done, a separate density matte will be required.* We will be able to use this matte with the light changes on step printers. Once a picture has been set up for printing, in this manner, it can be printed on either type of printer with the same matte producing the opticals and light changes in the final print. When printed optical effects are used with the step printers, density light-change boards are unnecessary. This, we feel, will be an advantage because it will eliminate any mis-lights. We also feel that the elimination of splices in the mattes will be a distinct advantage.

We do not necessarily believe that this system of printing is suitable for every 16mm laboratory, but it has been successful for us. Neither do we think it is the final answer, because new products will probably change some of our methods. However, we believe that we know how we can make conversions on present printers. And, where conversions will not work, we have ideas on how different types of printers can be built for new processes which have not yet been developed to where they may be introduced commercially.

* Since this paper was originally written, a method has been discovered which permits other types of wipes to be printed directly.

References

1. L. Sherwood, "Editing and photographic embellishments as applied to 16-mm industrial and educational motion pictures," *Jour. SMPE, 41:* 476–493, Dec. 1943.
2. P. S. Aex, "A photoelectric method for determining color balance of 16-mm Kodachrome duplicating printers," *Jour. SMPE, 49:* 425–430, Nov. 1947.

High-Constant-Speed Rotating Mirror

By J. W. BEAMS, E. C. SMITH and J. M. WATKINS

The rotating mirror is magnetically suspended in a high vacuum and spun by a rotating magnetic field. The mirror is accelerated to full speed in a way similar to that of the armature in an induction motor, but at running speed it performs as an armature of a synchronous motor. The frequency of the rotating field is determined by a piezoelectrically controlled circuit. Also it is free of hunting. The maximum rotational speed of the mirror is determined only by the strength of the mirror. Mirrors are described which rotate at 20,000 rps.

In a great many problems, where it is necessary to study accurately phenomena which occur in very short intervals of time, it is desirable to have a high-constant-speed rotating mirror.[1,2] It is particularly important that not only the number of revolutions per second of the mirror must be known with high precision, but the mirror must be free of so-called hunting or rapid variations in speed. This latter requirement of freedom from hunting is usually almost impossible to attain in practice, especially where the friction on the mirror or bearings requires that the drive deliver considerable power, i.e., when the frictional torques and the driving torques are large, small asymmetries in either give rise to hunting of the rotor. In the rotating mirror arrangement described in this paper, the total frictional torque is very small with the result that the speed can be made extremely constant and hunting, if present, is too small to be observable.

Presented on May 2, 1951, at the Society's Convention at New York, by J. W. Beams, E. C. Smith and J. M. Watkins, Rouss Physical Laboratory, University of Virginia, Charlottesville, Va. The research project upon which this paper is based was supported by Contract NOrd-7873 with the Navy Bureau of Ordnance.

Experimental Arrangement

Figure 1 is a schematic diagram of the apparatus, while Fig. 2 is a photograph of the suspended mirror with the vacuum chamber and one drive coil removed. This arrangement is the outgrowth of a series of experiments, using magnetically suspended rotors or centrifuges in a vacuum, carried out at the University of Virginia over a number of years.[3–7] The mirror R made of high-strength ferromagnetic material is suspended inside a glass vacuum chamber by the axial magnetic field of the solenoid S situated above the chamber. The vertical position of the rotor is

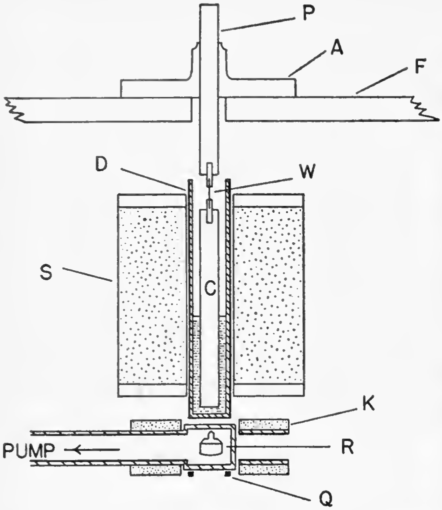


Fig. 1. Schematic diagram of high-constant-speed rotating mirror arrangement.

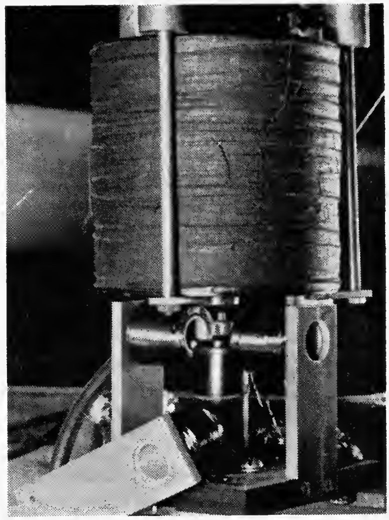


Fig. 2. Suspended mirror, with vacuum chamber and one drive coil removed.

maintained by the automatic regulation of the current through the solenoid S, while its horizontal position is determined by the symmetrically diverging magnetic field. The mirror R is spun by two pairs of coils K which produce a rotating magnetic field. The small coil Q is part of a tuned grid–tuned plate radiofrequency oscillator (Fig. 3) which regulates the current through S. It is so arranged that when the rotating mirror rises, the current through S decreases, while when it falls, the current in S increases in such a way as to maintain the mirror at the desired height without observable hunting. The steel cylindrical core C of the solenoid S is suspended by a small wire W from the adjustable support P. The core C is surrounded by a damping fluid as shown and serves to damp any horizontal motion of the rotor.

Suspending Circuit

The circuit, which automatically regulates the current through the solenoid S in such a way as to maintain the rotor at the desired vertical position, is shown in Fig. 3. The pickup coil Q is in the grid circuit of a 5-mc partially neutralized tuned grid–tuned plate oscillator. If the rotating mirror R moves downward and approaches the coil Q, the latter's impedance, with the proper setting of the oscillator, is changed in such a way as to lower the amplitude of oscillation in the circuit. This gives rise to a so-called error signal which is detected by a cathode-follower detector and appears as a reduction in potential across the resistance R_{12}. A portion of this potential change appears on the grid of a 6SJ7 which is one-half of a two-pentode mixer. Subsequently, this signal increases the potential on the grids of the three 6L6's in parallel, which increases the current through the solenoid S and in turn raises the rotating mirror R.

In order to prevent vertical oscillation of the rotor R the "error" signal is differentiated by the resistance R_{11}-capacity C_7 combination and mixed with the original error signal. Also,

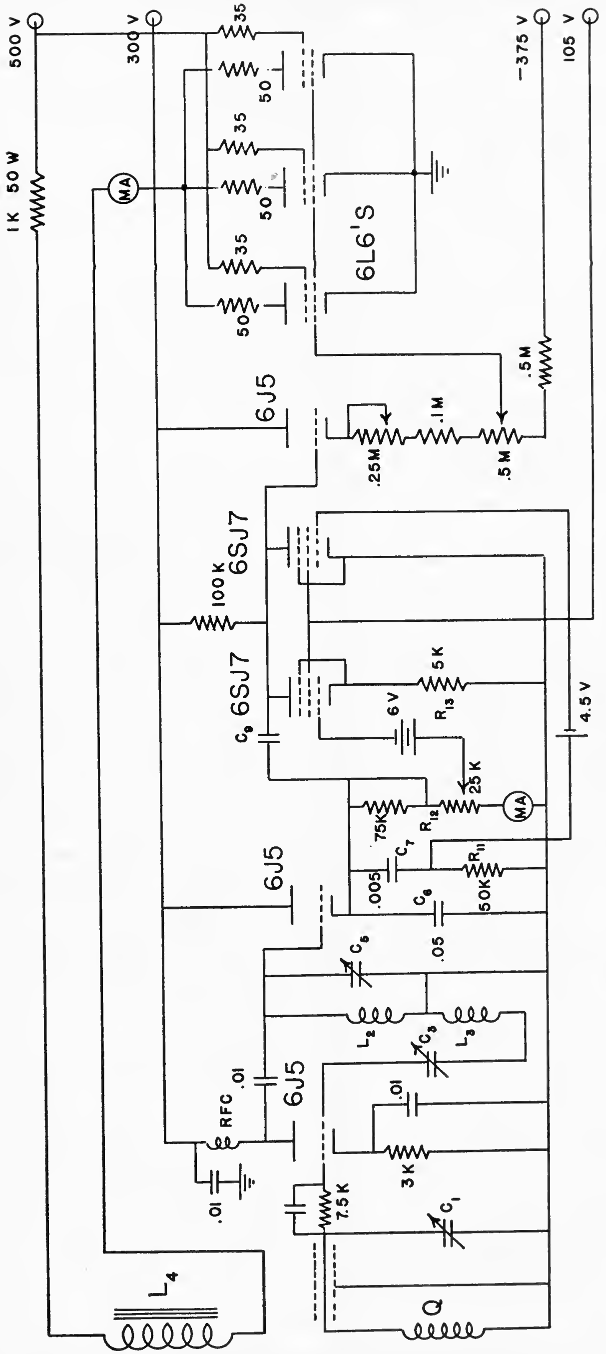


Fig. 3. Diagram of tuned grid-tuned plate radiofrequency oscillator and support.

the use of two 6SJ7 pentodes as mixers together with the negative feedback through resistor R_{13} and condenser C_9 produces increased stability. The power supplies were of the conventional regulated degenerative type.[8] The regulation of the 500-v supply is less critical than that of the 300-v supply so the latter is stabilized from the former. A variation of from 100 v to 135 v in the line voltage produces less than a 10-v change in the 500-v supply which in turn produces less than 0.02 v in the 300-v supply. The −375-v supply is obtained from a conventional transformer rectifier with condenser input filter system and stabilized with two VR 150's and one VR 75 in series.

The solenoid S consists of 25,000 turns of No. 28 insulated copper wire wound on a bakelite frame. Its inductance is 19.5 h (henrys) and its resistance, 1010 ohms. The cold-rolled steel, cylindrical core C of the solenoid ($\frac{7}{16}$ in. in diameter and $3\frac{7}{8}$ in. long) is suspended by a $\frac{5}{36}$-in. length of hardened 0.018-in. diameter piano wire W. The height of the core C is adjusted with a brass plunger P which fits into a brass disk A. The disk, which slides on the frame F, is adjusted by setscrews to the proper axial position so that the core remains approximately on the axis of the solenoid S when the current is raised to maximum value. The length of the core C and wire W are adjusted so that the period of the pendulum so formed is approximately that of the rotor S when given a horizontal displacement. The core hangs in a "dash pot" (a glass test tube flattened at the lower end and filled with SAE No. 10 motor oil) and damps any horizontal motion of the rotating mirror R. No motion of the rotor either in a horizontal or vertical direction can be detected by a 50× microscope focused on the scratches of the suspended mirror.

Rotating Mirror

For greatest stability of magnetic support it is desirable (although not absolutely necessary) to make the rotor as long or longer in the direction of the axis of spin than in the radial direction. On the other hand, for rotational stability, the moment of inertia around the axis of spin should be larger than that around the radial or perpendicular direction. Added to this, the rotor should be symmetrical around the axis of spin. It was found that a sharp cone on top of a short cylinder proved to be a very stable configuration. The faces of the mirror were ground on the cylindrical surface and the sharp cone concentrated the magnetic flux in the proper way to give stability. The edges of the top and bottom of the cylindrical portion were slightly beveled to prevent discontinuities (resulting from the mirror faces) from affecting the pickup coil Q.

The first mirrors were made of magnetic stainless steel (Carpenter 2B stainless 400). They were machined to shape and then heat-treated by the standard procedure to give good mirror surfaces and high strength. They were next ground to exact shape and the mirror surfaces lapped and polished. They were flat to roughly 0.2 wavelength of sodium light. Rotors of 0.5-in. diameter with mirror faces $\frac{1}{4}$ in. × $\frac{1}{4}$ in. were used successfully for long periods at 16,000 rps, but exploded at 18,500 rps. As a result the stainless steel has been replaced by hard high-strength alloy steel with the mirror faces covered with a very thin coating of aluminum. Ball bearings ground to the proper shape were found to be satisfactory when care was taken not to remove the temper during the grinding process. The mirror used at 20,000 rps was 0.5 in. from the bottom to tip of the cone and each of the six mirror faces was 0.25 in. in diameter. The first type of mirror is shown in Fig. 2. The rotating mirror was surrounded by an all-glass vacuum chamber with an optically flat glass window, through which the light passes, sealed on with low-vapor-pressure vac-

uum cement or wax. The chamber was evacuated by a standard forepump, diffusion-pump, cold-trap arrangement.

Driving Circuits

A schematic diagram of the drive circuit is shown in Figs. 4 and 5. The drive frequency is determined by a piezoelectric crystal-controlled electron-coupled oscillator operating at a frequency of 100,000 cycle/sec (Fig. 4). The crystal operates in a thermostat-controlled oven to improve stability. The oscillator is calibrated by zero-beating the 100th harmonic with the 10-mc wave broadcast by radio station WWV of the National Bureau of Standards. The oscillator may be tuned over a very narrow range and, in practice, set to give the lowest practical beat frequency. This procedure allows the oscillator frequency to be determined to about one part in 10^8. However, the published precision of WWV is only five parts in 10^8, so that when radio transmission irregularities are considered, the precision of the oscillator is not known to perhaps better than one part in 10^7. In practice, the oscillator circuit is operated for long periods of time and the drift is extremely small. If it becomes necessary to determine the frequency to better than one part in 10^7, it will be necessary to have a laboratory standard.

The output of the buffer amplifier of the oscillator is fed to a multivibrator frequency divider. The output of the multivibrator is a square wave of frequency $1/n \times 10^5$ cycle/sec, where n is an integer. The divider was designed for $n = 5$ or 6, i.e., frequencies of 20 kc or $16\frac{2}{3}$ kc, but other division ratios are easily obtained. This square wave is fed through an amplifier which serves as a filter. The resultant sine wave is passed through a phase-splitter and buffer-amplifier. The output (Fig. 5) is then amplified and transformer-coupled to the power tubes which operate as class C amplifiers with the drive coils resonant with the proper capacitors as the plate load.

The speed is measured by a method shown schematically in Fig. 6. Light is reflected from the mirror faces into a photomultiplier cell. This signal is amplified and applied to one pair of plates of an oscilloscope. The comparison frequency is applied to the other pair of oscilloscope plates so that the resultant Lissajous figure gives the frequency relationship. The comparison frequency was usually a standard audio-frequency oscillator except at operating speed, where the drive frequency or WWV was used as a comparison.

Operation

The procedure in starting the rotating mirror is to turn on the crystal oscillator in the drive circuit several hours before operation so that it will have sufficient time to reach thermal equilibrium. In the meantime, the pumps are started and the chamber surrounding the rotor evacuated to 10^{-6} mm Hg pressure or below. The mirror is then supported and the power applied to the driving circuit. In practice the support circuit approaches equilibrium in a relatively short time. The rotating field produced by the two pairs of coils K (Fig. 1) induces eddy currents in the mirror and it starts spinning. Consequently, the mirror acts as a high-resistance armature of an induction motor and continues to accelerate.

When the mirror speed approaches within about 40 rps of the frequency in the coils K, the rate of acceleration falls off, but if the pressure in the vacuum chamber is below 10^{-6} mm Hg the rotating mirror will continue to accelerate until its rotational speed approaches closely enough to the frequency of the rotating magnetic field to "lock in." When this occurs, the rotating mirror operates as an armature of a synchronous motor and spins without observable hunting at a rotational speed equal to the drive frequency. Consequently,

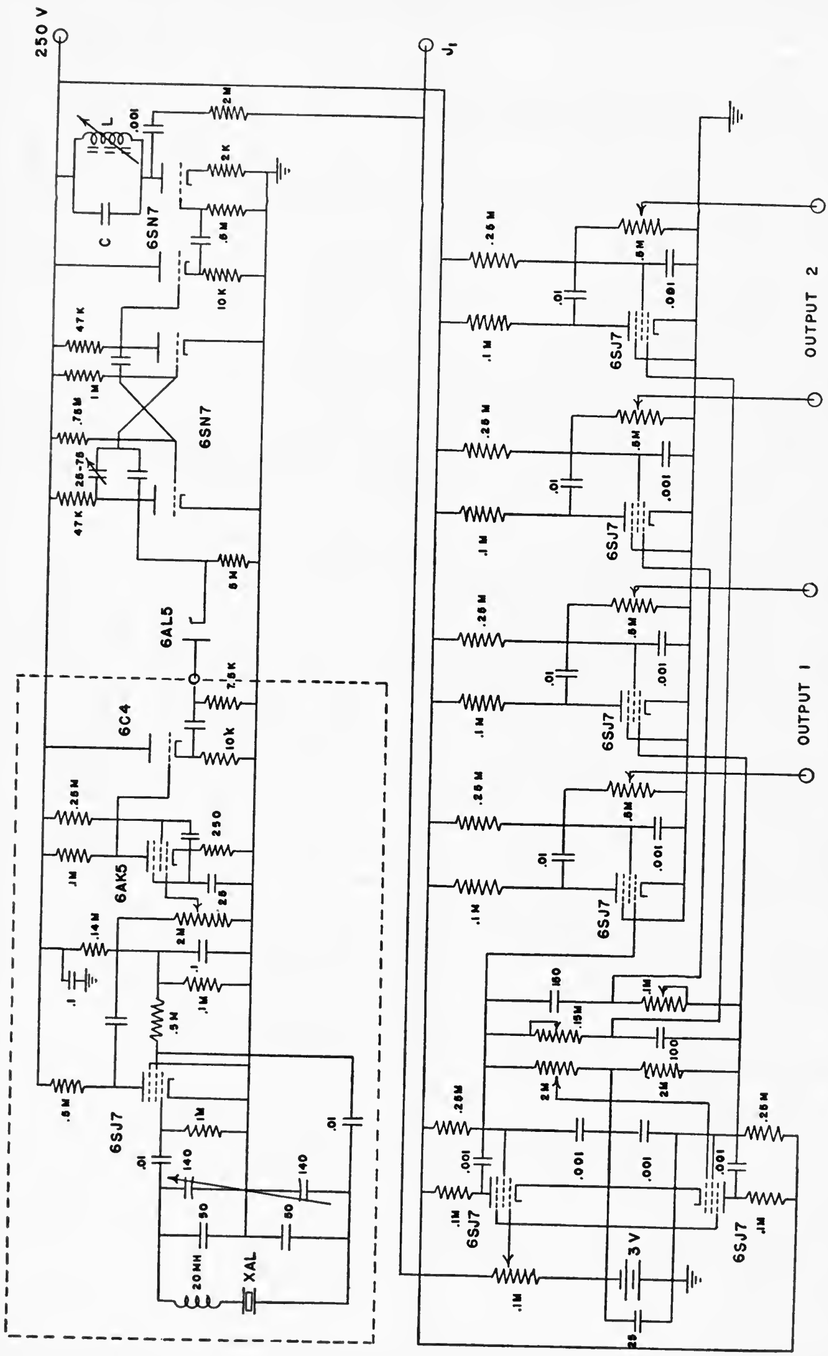


Fig. 4. Drawing of crystal-controlled oscillator and multivibrator frequency divider.

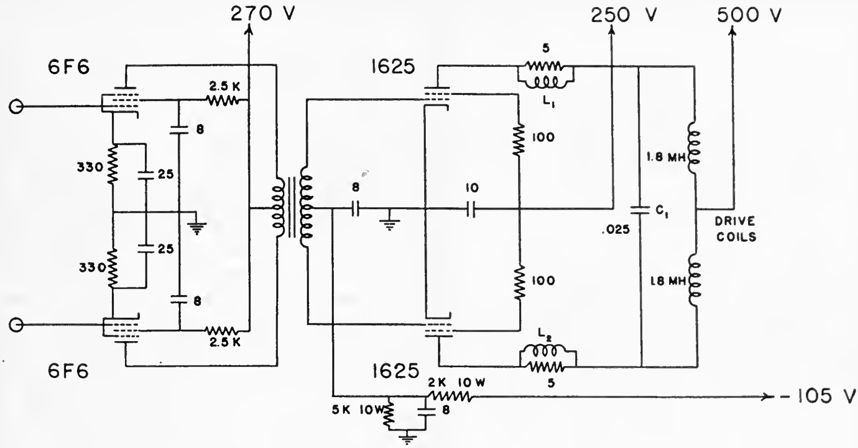


Fig. 5. Drive amplifier.

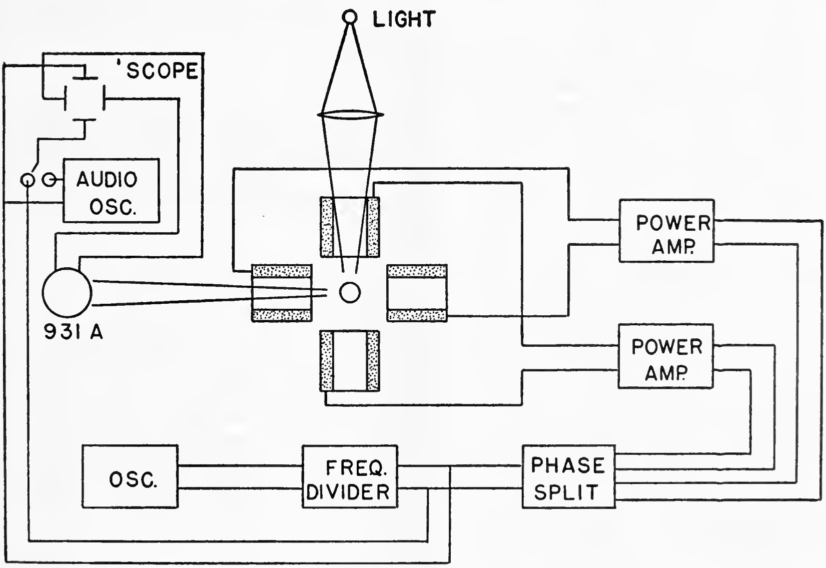


Fig. 6. Scheme of speed-measuring method.

the rotational speed of the mirror is known with the same precision as that of the master driving oscillator. Usually it requires more time to accelerate the rotating mirror the last 40 rps than to bring it up to this speed since the torque falls off very rapidly as the "slip" becomes small. As a result, it is usually advantageous to disconnect the crystal oscillator from the phase-inverter and substitute an audio oscillator during the acceleration period. In this way the drive frequency is set at 50 or 60 cycles above the desired running speed. When

the speed of the mirror slightly exceeds the desired running speed, the audio oscillator is disconnected and the crystal control substituted. The mirror then decelerates slowly and "locks in." When the mirror first "locks in" it hunts with a considerable amplitude, but in a few minutes this damps out and becomes too small to observe (less than 10^{-3} radian/sec). Since the rotor speed is over 10^5 radian/sec the error introduced by hunting is less than one part in 10^8.

With the circuit of Fig. 5 and a power input to the coils K of 150 w or 1.6 amp in the coils, the mirror accelerated at the rate of approximately 1000 rps/min until the "slip" frequency became about 50. However, with this much power input it is necessary to cool the coils with a small fan. On the other hand, when running speed is obtained, the power in the drive coils should be considerably reduced. The temperature of the mirror increases a few degrees during the acceleration period if the power input is not greater than indicated above. At running speed the rotor temperature decreases slowly to practically that of the surrounding walls. By removing the driving torque and permitting the mirror to "coast" freely, the deceleration is found to be extraordinarily small. As a matter of fact, the measured deceleration can be accounted for as due only to the friction of the residual gases surrounding the rotor. As a result, in order to bring the mirror to rest, it is necessary to reverse the direction of the rotating magnetic field and drive it down, otherwise it would take a very long time for the rotor to come to rest.

The above rotating-mirror arrangement is especially useful when phenomena which occur in very short periods of time must be studied with precision. It was developed for photographing the successive stages of sparks in different gases and the various stages of vacuum sparks. Also, it is being applied in a study of the velocity of light through liquids as a function of the wavelength of the light. Due to the high precision with which the rotational speed is known (one part in 10^7) and its freedom from hunting, the arrangement is almost ideally suited to the measurement of the velocity of light in a vacuum. However, for highest precision, the light path should be of the order of a mile in length and this distance is very difficult to measure and maintain with a precision of one part in 10^7. The maximum rotational speed of the mirror is limited only by the mechanical strength of the mirror. Consequently, by reducing the size of the rotating mirror higher speeds can be obtained. At the present time, a rotating mirror which spins at 10^5 rps is under development.

Acknowledgment: It is indeed a pleasure to acknowledge the valuable help of Dr. P. B. Buck during the initial stages of this work.

References

1. J. W. Beams, "Spectral phenomena in spark discharges," *Phys. Rev., 35:* 24–33, Jan. 1930; "The propagation of luminosity in discharge tubes," *ibid., 36:* 997–1001, Sept. 1930; "High rotational speeds," *J. Applied Phys., 8:* 795–806, Dec. 1937.
2. C. D. Miller, "The optical system of the NACA 400,000-frame-per-second motion picture camera," *U.S. NACA ARC No. E6C25*, 1946; *U.S. NACA TN No. 1405*, Aug. 1947.
3. F. T. Holmes and J. W. Beams, "Frictional torque of an axial magnetic suspension," (letter to the Editor), *Nature, 140:* 30–31, July 1937.
4. F. T. Holmes, "Axial magnetic suspensions," *Rev. Sci. Instruments, 8:* 444–447, Nov. 1937.
5. L. E. MacHattie, "Production of high rotational speed," *Rev. Sci. Instruments, 12:* 429–435, Sept. 1941.
6. J. W. Beams, J. L. Young and J. W. Moore, "The production of high centrifugal fields," *J. Applied Phys., 17:* 886–890, Nov. 1946.

7. J. W. Beams, "High centrifugal fields," *J. Wash. Acad. Sci.*, *37:* 221–244, July 1947.
8. W. C. Elmore, "Electronics for the nuclear physicist—IV," *Nucleonics*, *2:* 50–58, May 1948.

Discussion

M. L. Sandell: If you wanted to slow up the rotor faster than happens directly from friction, could you do it by reversing the field?

Dr. J. W. Beams: Yes, that is the best way of doing it.

E. Salzberg: I would like to know whether the techniques you have developed in supporting a rotating object have found any application in industry or commerce?

Dr. Beams: Well, I don't know. This is a research tool as far as I know. Besides, in the spinning of mirrors, I think probably it will be very useful as an aid in producing a new type of centrifuge. I believe that it is going to allow us to increase the precision of the measurement of molecular weights, especially of the proteins.

The magnetic suspension used for supporting the mirror in these experiments may be slightly modified to make it into an excellent magnetic balance. We have succeeded in weighing weights of one milligram with a precision of about one billionth of a gram. This, of course, may find considerable use in industry.

Mr. Salzberg: Would it be possible to eliminate the use of the vacuum in rotating at relatively low speed?

Dr. Beams: Yes. However, the air friction goes up pretty rapidly with rotor speed.

Kenneth Shaftan: What material do you use?

Dr. Beams: We are using steel mostly. The rotor is made of the best steel we can get. We made some experiments on the bursting of different steels and we ran a long series on ordinary commercial ball bearings and on selected ball bearings. It turned out the ball bearings burst at the same peripheral speed if made of the same material. There were a great many flaws in the larger ball bearings. The probability of the rotor going up to full speed was roughly inversely proportional to the diameter of the rotor. I think that this result can be explained metallurgically.

Anon: What was the measurement between the solenoid field and the rotor itself?

Dr. Beams: Do you mean what distance?

Anon: Yes.

Dr. Beams: All the way from a few millimeters to 6 or 8. It is a variable thing, depending upon the field in the solenoid and its gradient at the rotor position.

Anon: What order of magnitude of power inversely is required to spin the bearing rotor?

Dr. Beams: Now, this is a relative matter, of course. I had one that was small, near $\frac{1}{16}$ in. in diameter, which started spinning slowly when the light from a Western Union electric arc was focused on its periphery. In other words, the light pressure was sufficient to spin it.

In this rotating mirror we had 1.6 amp to the coil and it accelerated at the rate of 1000 rpm. We try in most of our experiments to bring the rotor up as slowly as we can; by accelerating it faster, more heat is generated in the rotor. But under about one ampere in the coil the rotor increases in temperature less than 10°.

A. W. Carpenter: In bursting ball bearings could you tell me offhand within what angle it proved to be splaying or clipping?

Dr. Beams: Well, they sort of powdered and completely disintegrated. One also notices a little yellow light, like on a grinding wheel. You, of course, look through a right-angle mirror to see the yellow light.

E. A. Andres, Sr.: If I understood you correctly, you said you had 1.6 amp accelerated at 1000 rps...

Dr. Beams: No, 1000 rpm.

Mr. Andres: I would like to know how you made the measurement.

Dr. Beams: By photoelectron multiplier tube and a light-beam arrangement.

C. D. Miller: Dr. Beams, as you know at NACA we used a system similar to the one developed by you for supporting and driving a rotor used in a camera with which we took pictures at speeds up to 800,000 frame/sec. We used a rotor weighing about two-thirds of a pound,

about three inches long and about an inch in diameter.

I was interested in your remarks about the heating effect. We were not able to get an extremely good vacuum, as you have, because of certain mechanical limitations involved in our optical system. Because of the consequent high slip and resulting eddy currents, we ran into very serious heating of the rotor.

We eliminated the heating by resorting to what I call a self-synchronous motor. We cross-magnetized the rotor and drove it up to a few revolutions per second as an induction motor. Then, with two small coils alongside the lower end of the rotor, 90° apart, we picked up a four-phase voltage induced by the cross magnetization. We amplified this four-phase pickup, through both voltage and power amplifiers, and fed the output into the driving coils. We adjusted the positions of the pickup coils so that the rotating field was a little ahead of the cross magnetization of the rotor. The rotor then accelerated as a synchronous motor, and we avoided the heating altogether.

Dr. Beams: Yes. Yours was a very beautiful experiment. The method you used was certainly a good one. We have had to use a similar sort of scheme where we cannot have any temperature rise. The only reason we did not do it here is that the small mirrors do not get too hot. On the other hand, for larger rotors this is necessary.

Mr. Miller: I was wondering whether you found that the cross magnetization of the rotor would cause any undesirable effects in your experiments.

Dr. Beams: No, the cross magnetization seems not to upset anything else.

Anon: Mr. Miller, how much temperature rise did you encounter in the rotor when attempting to drive it up to full speed as an induction motor?

Mr. Miller: I did not measure the temperature rise except by touching the rotor with the hand. It was obviously excessive.

R. O. Painter: I wonder why the supporting field does not introduce eddy current flow. As I have it, there would be eddy current loss caused by this field since it fans out in the rotor.

Dr. Beams: Well, you see the magnetic field comes down uniformly across the rotor since the latter has a high permeability. Hence, there is no current flow.

Mr. Painter: Is it not generating eddy currents in the rotor periphery? You have a radial magnetic field.

Dr. Beams: You have a radial electrical field as it works out in practice. On the other hand, you have no closed circuit for the current unless the spin axis of the rotor makes a sizable angle with the direction of the magnetic field.

Mr. Painter: Between the center and the outside?

Dr. Beams: There is an electrical potential between the center and periphery of the rotor, but no current can flow.

Report of SMPTE Standards Committee

By FRANK E. CARLSON, Committee Chairman

The Standards Committee has continued to function with the type of organization and in accordance with the policies described in the preceding report.[1] This, the final report of the present Committee, includes not only a review of the work of the past two years, but also observations regarding the organization and policies of the Committee in the light of past experience.

Organization

The current practice of naming the Chairmen of the several Engineering Committees as members of the Standards Committee has proven quite satisfactory and it is recommended that this be continued. The objectives sought in appointing to this Committee the Chairmen of ASA sectional committees having interests closely related to the motion picture industry have not been realized, possibly because the activities of those committees during this period did not happen to bear on subjects of interest to motion pictures. In any event, since an important part of the related fields is represented in the Photographic Standards (Correlating) Committee, it seems desirable to reconsider the importance of such appointments. Participation by the Motion Picture Research Council and the few members-at-large has been commendable although, in the case of the MPRC, it was sometimes felt that the Committee would benefit if it were better informed of the Council's standards activities and interests.

Policies

The present practice of publication for trial and criticism, reviews, approvals, and reapprovals of proposed standards is different from the practices in many other and related fields. Unquestionably such thoroughness serves a useful purpose, but it must also be conceded that it adds to the Society's cost for processing standards and, in large measure, duplicates work which is the logical assignment of Sectional Committee PH22 of ASA. Since this Sectional Committee is sponsored by the SMPTE, and its membership is reviewed and approved by the Board of this Society, it is suggested that this present duplication of responsibility and effort be studied.

Coordination of Photographic Standards Work in ASA

Early in 1950 the Standards Council of ASA authorized the formation of a Photographic Standards (Correlating) Committee and, in accordance with ASA procedure, delegated to that Committee

Submitted as of December 27, 1951, by the Society's Standards Committee Chairman, Frank E. Carlson, General Electric Co., Nela Park, Cleveland 12, Ohio.

general administrative and supervisory responsibilities in this field. Prior to this time all proposed photographic standards were classified in the "miscellaneous" group and, like other miscellaneous standards, were identified by numbers which included the prefix letter Z. Formerly a standard approved by the old Sectional Committee Z22 had to be referred to the ASA Board of Examination which in turn had to refer it to the full Standards Council consisting of over 70 members. Since the formation of the Correlating Committee all proposed photographic standards (as well as revisions of old standards) are identified by the prefix PH. These proposals from one or another of the new Sectional Committee for photography go directly to the Correlating Committee and then to a six-man Board of Review for final approval. Thus, the formation of the Photographic Standards (Correlating) Committee has made possible substantial savings in both time and money.

It will be noted that, in subsequent sections of this report, standards or proposals are identified by Z22 numbers in some cases and PH22 numbers in others. This obviously reflects the change in organization just described. In the future all motion picture standards will be identified by the prefix PH22 as new standards are completed and old ones reviewed. Other photographic standards (formerly identified by Z38 numbers) will, in the future, be identified by the prefix PH1, PH2, PH3, or PH4, depending upon which of the four other new Sectional Committees for photography sponsored the proposal.

Standards Completed in 1950–1951

The following ten standards have been processed since the last report and have been adopted by ASA:

Z22.7-1950: Location and Size of Picture Aperture of 16mm Motion Picture Cameras[2]

Z22.8-1950: Location and Size of Picture Aperture of 16mm Motion Picture Projectors[2]

Z22.19-1950: Location and Size of Picture Aperture of 8mm Motion Picture Cameras[2]

Z22.20-1950: Location and Size of Picture Aperture of 8mm Motion Picture Projectors[2]

PH22.71-1950: Cutting and Perforating Dimensions for 32mm Sound Motion Picture Negative and Positive Raw Stock[3]

PH22.72-1950: Cutting and Perforating Dimensions for 32mm Silent Motion Picture Negative and Positive Raw Stock[3]

PH22.73-1951: Cutting and Perforating Dimensions for 32mm on 35mm Motion Picture Negative Raw Stock[4]

PH22.74-1951: Zero Point for Focusing Scales on 16mm and 8mm Motion Picture Cameras[4]

PH22.76-1951: Mounting Threads and Flange Focal Distances on 16mm and 8mm Motion Picture Cameras[4]

PH22.82-1951: Sound Transmission of Perforated Projection Screens[5]

Additionally, Z22.78-1950, Mounting Frames for Theater Projection Screens,[2] was adopted by ASA but not processed by the Standards Committee. This standard was developed by a subcommittee of ASA Sectional Committee Z22.

Similarly, the following three standards adopted by ASA were developed by the Joint SMPTE-MPRC Committee on Test Films:

Z22.79-1950: 16mm Sound Projector Test Film[2]

Z22.80-1950: Scanning-Beam Uniformity Test Film for 16mm Motion Picture Sound Reproducers (Laboratory Type)[6]

Z22.81-1950: Scanning-Beam Uniformity Test Film for 16mm Motion Picture Sound Reproducers (Service Type)[6]

The difficulties encountered in attempting to process a standard for 16mm and 8mm sprockets were described in the preceding report.[1] Accordingly, the Committee has published[7] an SMPTE Recommendation for 16mm and 8mm Sprocket Design for the guidance of sprocket designers. This material is in

a format such that it can be included in the Society's Standards Binder.

The Standards Committee has also completed its work on the following four proposals which have been submitted to ASA with the recommendation that they be adopted as American Standards:

PH22.11: 16mm Motion Picture Projection Reels[8]

PH22.83: Edge Numbering of 16mm Motion Picture Film[9]

PH22.24: Splices for 16mm Motion Picture Films for Projection[10]

PH22.77: Splices for 8mm Motion Picture Film[10]

Standards Currently in Process

PH22.15: Emulsion and Sound Record Positions in Camera for 16mm Sound Motion Picture Film[11]

PH22.16: Emulsion and Sound Record Positions in Projector for Direct Front Projection of 16mm Sound Motion Picture Film[11]

Both of the above are proposed revisions of Z22.15-1946 and Z22.17-1947, the most important detail of which is elimination of reference to the "guided edge." As sometimes happens in a case such as this, additional suggestions for improvement of the revision have been received with the result that a revised revision of the proposal is scheduled for republication shortly.

PH22.86: Dimensions for Magnetic Sound Tracks on 35mm and 17½mm Motion Picture Film[12]

PH22.87: Dimensions for Magnetic Sound Track on 16mm Motion Picture Film[12]

PH22.88: Dimensions for Magnetic Sound Track on 8mm Motion Picture Film[12]

These badly needed proposals are the work of the Subcommittee on Magnetic Recording of the Sound Committee and the comments which have resulted from preliminary publication are now being reviewed by that Committee.

Z22.75: A and B Windings of 16mm Raw Stock Film With Perforations Along One Edge[13]

This proposal, originally an SMPE Recommendation adopted in 1941, has given the 16mm and 8mm Motion Pictures Committee a great deal of trouble. It was first published as a proposed standard in September, 1949; the present revision of the proposal, which appeared in January, 1951, has brought forth suggestions for further changes, with the result that it has been again referred to the sponsoring Committee.

PH22.84: Dimensions for Projection Lamps, Medium Prefocus Ring Double-Contact Base-Up Type[3]

PH22.85: Dimensions for Projection Lamps, Medium Prefocus Base-Down Type[3]

These two proposals, developed by the 16mm and 8mm Motion Pictures Committee, seem to be about ready for final action by the Standards Committee on the question of submittal to ASA.

PH22.1: Cutting and Perforating Dimensions for 35mm Motion Picture Film — Alternate Standards for Either Positive or Negative Raw Stock[14]

The history of this proposal since 1932 is briefly set forth in the *Journal* and is an example of the complexity of the problems that frequently confront the Film Dimensions Committee.

Other proposals on the Agenda of the Standards Committee which have not yet reached the stage of publication for trial and comment include the following:

Revision of Z22.41-1946, Sound Records and Scanning Area of 16mm Sound Motion Picture Prints, again with particular reference to the question of "guided edge." The Sound Committee is considering this question to determine what can be done to establish consistency with related standards without degradation of 16mm sound quality.

Aperture Calibration of Motion Picture Lenses, a proposal developed by the Optics Committee, has encountered strong criticism in the initial ballot of the Standards Committee on the question of preliminary publication.

Enlargement Ratio for 16mm to 35mm Optical Printing is a new proposal developed by the Laboratory Practice Committee and will probably appear in an early issue of the *Journal.* [See the Jan. 1952 *Journal.*]

16mm Motion Picture Projector for Use With Television Film Chains Operating on Full-Storage Basis. This is a proposal developed by the joint RTMA-SMPTE Committee on Television Film Equipment and is encountering opposition on the Standards Committee initial ballot.

Under ASA procedure, existing standards are re-examined periodically for the purpose of determining whether the Standard should be reaffirmed in its present form, be revised in the light of new developments or changing practices, or rescinded because it is no longer of value. The responsibility for such review is delegated to the several Engineering Committees and two of them have recently submitted recommendations to the Standards Committee for further action. These include:

Nomenclature for Electrical Filters, Z22.33-1941. The Sound Committee has recommended that this Standard be discontinued because it finds that the method described for designating electrical filters has had very little use and has no further value.

Emulsion Position in Projector for Direct Front Projection of 16mm Silent Motion Picture Film, Z22.10-1947.

Emulsion Position in Projector for Direct Front Projection of 8mm Silent Motion Picture Film, Z22.22-1947. Here too, the Committee on 16mm and 8mm Motion Pictures recommends that these standards be discontinued because films for projection are produced by such a variety of processes that the Standards are no longer of value.

Finally, the Engineering Vice-President has asked the Standards Committee to assist in another effort to develop a glossary. As a first step in this program, work done in the early 1940's on this subject is being subdivided by the Society's Staff Engineer into parts corresponding to the scopes of the several Engineering Committees. Thus, work already done need not be duplicated by those Committees. It is expected that this initial work will be completed in time for the several Committees to begin work early in their new terms.

References

1. "Report of the Standards Committee," *Jour. SMPTE, 54:* 102–105, Jan. 1950.
2. "New American Standards," *Jour. SMPTE, 54:* 494–507, Apr. 1950.
3. "Standards," *Jour. SMPTE, 56:* 235–246, Feb. 1951.
4. "Three New Standards," *Jour. SMPTE, 56:* 684–689, June 1951.
5. "New American Standards," *Jour. SMPTE, 57:* 170–171, Aug. 1951.
6. "New American Standards," *Jour. SMPTE, 55:* 117–119, July 1950.
7. "Recommendations for 16mm and 8mm Sprocket Design," *Jour. SMPTE, 54:* 219–228, Feb. 1950.
8. "Proposed American Standard, 16mm Projection Reels," *Jour. SMPTE, 54:* 229–231, Feb. 1950.
9. "Edge Numbering of 16mm Motion Picture Film," *Jour. SMPTE, 56:* 115, Jan. 1951.
10. "Splices for 16mm and 8mm Film," *Jour. SMPTE, 56:* 354–361, Mar. 1951.
11. "Revision of PH22.15 and PH22.16," *Jour. SMPTE, 56:* 559–561, May 1951.
12. "Proposed American Standards," *Jour. SMPTE, 57:* 71–74, July 1951.
13. "A and B Windings of 16mm Raw Stock Film With Perforations Along One Edge," *Jour. SMPTE, 56:* 112–113, Jan. 1951.
14. "Proposed American Standard," *Jour. SMPTE, 57:* 275–278, Sept. 1951.

71st Semiannual Convention

The Spring Convention at The Drake in Chicago on April 21–25 is well planned already by many good hands, some of whom were noted in the report in the January *Journal*.

BUT **now is the time for all good authors** to hasten information about their papers for the Convention to the proper authority.

If you don't have an Authors' Form or can't readily get one from one of the Papers Committeemen listed in the January *Journal*, ask the Society's headquarters office for one.

AND in the meantime, **not merely in posthaste but by wire,** advise the 71st Convention Program Cochairman on the spot in Chicago:

Telegraph: George W. Colburn, 164 N. Wacker Drive, Chicago 6, Ill.

The sooner you send word, the easier will be the work of arranging the program in the form of sessions, which is the job of the Program Cochairmen, R. T. Van Niman and George Colburn.

Convention Vice-President Bill Kunzmann gave a detailed report of plans for the Convention to the Society's Board of Governors in January, and from that report and later information from Bill, as well as from C. E. Heppberger, we have the following roster of the folks who will put on the Chicago Convention:

Program Cochairmen — R. T. Van Niman and George W. Colburn

Local Arrangements — C. E. Heppberger

High-Speed Photography — Richard O. Painter

Hotel Reservations and Transportation — W. C. De Vry

Luncheon and Banquet — George W. Colburn

Membership and Subscriptions — Ray Gallo and Samuel R. Todd

Motion Pictures Program — L. E. Weber, assisted by R. J. Sherry

Projection, 16mm — E. W. D'Arcy

Projection, 35mm — I. F. Jacobsen, assisted by Officers and Members of Local 110, IATSE

Public Address and Recording — Robert P. Burns

Publicity — Harold Desfor and Leonard Bidwell

Registration and Information — James L. Wassell, assisted by E. W. D'Arcy, J. E. Dickert, Steve Hunter, C. L. Lootens, K. M. Mason, John S. Powers and Reid H. Ray

Television — William C. Eddy

Ladies' Registration — Mrs. George W. Colburn and Mrs. C. E. Heppberger, Cohostesses, assisted by the wives of the Central Section's Officers and Managers

Early in March, all members will receive the Advance Notice of the Convention, which will contain a condensed schedule of the Convention sessions and will have attached the usual tear-off postal for making hotel reservations. Bill Kunzmann has received from John R. Bogardus, Front Office Manager, The Drake, Lake Shore Drive & Upper Michigan Ave., Chicago 11, Ill., the following rates:

Single room, per day	\$5.50; 6.00; 6.50; 7.00; 7.50.
Double room with twin beds, per day	\$9.00; 10.00; 11.00; 12.00; 14.00; 15.00.
Suite parlor and one bedroom, per day	\$16.00; 18.00; 19.00; 26.00; 33.00; & up.

Board of Governors Meeting

The Society's Board of Governors held its first 1952 meeting on January 24, in New York City. This is the meeting at which the members of the Board examine the previous year's operations, comparing carefully the report of actual performance for last year against the budget that was set up in January 1951.

EXECUTIVE COMMITTEE

Most significant administrative development of 1951 was the appointment by President Peter Mole of an Executive Committee which will assume some of the operational advisory functions formerly exercised directly by the Board of Governors. Growth of the Society's business and the importance of a number of its activities in the almost daily evolution of television and the current technical growth of motion pictures call for closer supervision of the headquarters operations than the Board of Governors could provide with its regular quarterly meetings. As a consequence, the Executive Committee will meet monthly, or more often if necessary, consult with the staff, examine the precise details of operation on a month-to-month basis and will submit recommendations for consideration by the Board of Governors when that body meets every third month. Under this arrangement, matters of general policy and questions of membership or industrial services provided by the Society can receive proper Board attention while details of execution will in general be left to the discretion of the executive body.

ENGINEERING

Test film operations were placed on a somewhat more secure footing when Fred Whitney joined the headquarters staff during the early part of 1951 and took charge of test film quality control. Precision required by American Standards or by specifications developed by Society committees for motion picture test films demands careful supervision of production. In addition, development of certain new test films through the coming year will necessitate not only agreement on the manner in which the films are produced but also agreement on standard methods of testing. It will be Mr. Whitney's responsibility to spell out these test methods in detail and submit them for consideration by the Test Film Quality Control Committee.

PUBLISHING

The report of the Editorial Vice-President pointed out *Journal* changes made during 1951 which have been considered a marked improvement. The new style provides more words per page and the combination of type face, line length and line spacing contributes to easier reading and yields more printed words per publication dollar than was possible in the older format. With the new format now well in hand, the major objective for 1952 is the adoption of more realistic publication dates. The first three issues for 1952 will probably be somewhat thinner than usual and it is expected that the May issue will be out by the 15th of that month.

The actual cost of producing the twelve copies of the *Journal* which each member receives annually is a figure that has been quite difficult to arrive at, considering the recent major changes in accounting, the manner of operating Society Headquarters plus the format changes of the past year. Since things are now settling down, the Board asks that Headquarters prepare such a cost analysis with a view toward determining whether or not each member's dues pays his share of the cost of operating the Society. Figures that result from pro rata allocation of costs depend, of course, on membership. Unit costs go down as the total number of members goes up. That brought up the question of membership solicitation activities for last year and also for 1951.

MEMBERSHIP

A new committee, under the Chairmanship of Ray Gallo of Quigley Publications and with Beatrice Conlon of the Society Headquarters as full-time Secretary, is attempting something new in the way of membership work. Between 65 and 100 company or city member-delegates are being selected and each will be armed

with advance information about conventions, Society committees, Section meetings and membership and publications ammunition. Each of these member-delegates will be the focal point for Society information in his own community. It is hoped that many questions about the SMPTE, its engineering activities and membership requirements can be answered on the spot, to the benefit not only of the inquirer but of the Society as well.

SECTIONS

Reports of the three Section Chairmen were read into the record and it was noted that extra effort at organizing Section meeting programs was almost invariably rewarded by an increase of attendance, entirely justifying the added costs of rented chairs or screening-room facilities. Popular reaction to the repeating of Convention papers at Section meetings brought an official request for the recording on magnetic tape of certain papers for re-presentation with accompanying slides. It was suggested that a small library of such papers be assembled and made available in appropriate batches for regional meetings or student chapter sessions. There was also a formal recommendation that the Student Chapters in Hollywood and in New York should function under the supervision of the local Section Chairmen and Boards of Managers. This would probably result in the more efficient use of funds and perhaps encourage Chapter participation in local Section meetings.

CONVENTIONS

The report of the Convention Vice-President concluded, with some enthusiasm, that the two Conventions held in 1951 had drawn better attendance than any in previous years. As a consequence, plans for the Spring and Fall Conventions in 1952 are being adjusted to provide facilities for the larger registration. The following dates were reported to and approved by the Board of Governors:

71st Convention: The Drake, Chicago, Ill., April 21–25, 1952
72nd Convention: Hotel Statler, Washington, D.C., October 6–10, 1952
73rd Convention: Hotel Statler, Los Angeles, Calif., April 26–30, 1953
74th Convention: Hotel Statler, New York, N.Y., October 4–9, 1953

Engineering Activities

New Chairmen Engineering Committees are appointed in accordance with Section V of the Society Bylaws, which states that the term of appointment expires every two years, along with the term of the appointing officer (the Engineering Vice-President) and further that Committee Chairmen are eligible for one reappointment, or for a total service of 4 years. (There is no limit on the reappointment of members, except that imposed by their degree of interest in the work of the committee.)

The four-year limitation now requires that Fred Bowditch as Engineering Vice-President appoint new chairmen to six committees, four of whom are:

Standards, Henry Hood, Eastman Kodak
16 & 8, Malcolm Townsley, Bell & Howell
Sound, John Hilliard, Altec Lansing
Motion Picture Studio Lighting Process Photography, John W. Boyle

The two committees still without new Chairmen are Color and High-Speed Photography. It is expected that they can be announced in the next *Journal*.

ISO The Technical Committee on Cinematography of the International Organization for Standardization (ISO TC/36) was canvassed as to their interest in a meeting in New York on June 9 and 10, 1952, as mentioned in the previous issue. Affirmative replies have since been received from Belgium, Canada, France, Germany, Italy and the United Kingdom. Based on this response, the Chairman of the ASA Sectional Committee PH 22, Dr. D. R. White, and the SMPTE Engineering Vice-President, Fred Bowditch, recommended to the ASA that the meeting be scheduled. A proposed Agenda is now being formulated, on the recommendations of the SMPTE Engineering Committees, secured in anticipation of such a meeting and including items submitted by several of the member nations. ISO procedure requires the Agenda to be circulated to all members four months prior to the meeting, in this instance by February 9, 1952. As Secretariat the United States will chair the meeting.—*Henry Kogel*, Staff Engineer.

Book Reviews

Fundamental Mechanisms of Photographic Sensitivity

(Proceedings of a Symposium held at the University of Bristol in March 1950.) Edited by J. W. Mitchell. Published (1951) by Butterworths Scientific Publications, London. Distributed in U.S.A. by Academic Press, 125 E. 23 St., New York 10. i-viii + 347 pp. + 270 illus. 7 × 9¾ in. Price $9.50.

This represents an excellent and up-to-date review of data and theories on the fundamental mechanisms of photographic sensitivity. Original papers as presented at an International Conference in Bristol, England, in March 1950, have been assembled in book form by the editor.

By arranging the papers in groups, such as "Photographic Sensitivity" and "Latent Image Formation," the editor has made it convenient for the reader to follow the latest trends and developments in these concepts. Professor N. F. Mott, in an introduction to the book, outlines the latent image theory as proposed by him and Gurney in 1938 and gives its present status, pointing out the problems which still need explanation. This introduction will be helpful to those who are not too familiar with the subject.

The book contains contributions and first publications of papers from a large number of European, British and American scientists. It is interesting to note from these papers that their various observations and theories about latent image formation, photographic sensitivity and optical and chemical sensitization begin to dovetail with the basic concept of Gurney and Mott and the evolution of this theory by concepts proposed by Pohl, Stasiw and Teltow, West, Mitchell and others.

The book also contains a series of articles under the general headings: "Physical Properties of Silver Halide," "Production and Properties of Silver Halide Grains in Photographic Emulsions" and "Nuclear Track Emulsion." A summary prepared by the editor after the conference gives a critical review of the status of the theory of the physical properties of the silver halides and the theory of photographic sensitivity as it appeared to him.

The book will be of interest primarily to those working in the field of photographic research and development; however, it should also appeal to those working on practical applications of photography and interested in knowing what makes photography work. The book is well printed and illustrated.—*Herman H. Duerr*, Ansco, Binghamton, N.Y.

Einführung in die wissenschaftliche Kinematographie (Introduction to Scientific Motion Picture Photography)

By Dr. Werner Faasch. *In German.* Published (1951) by Verlag von Wilhelm Knapp/Halle (Saale), Germany. 76 pp. + 63 illus. 5¾ × 8 in. Available in U.S.A. from Stechert-Hafner, Inc., 31 E. 10 St., New York 3. Price $1.30.

At this time, when photography is being recognized more and more as an indispensable tool for scientific and technical investigation, the appearance of any book which surveys some part of the field should not be ignored. This book is intended merely as an introductory survey to the applications of motion picture photography as a means of scientific study.

The opening chapter is concerned with time-lapse and high-speed motion picture studies, and in particular with German apparatus for use in these fields.

Among the special applications of motion picture photography dealt with in succeeding chapters are motion photomicrography, x-ray and electron microscope motion photography, endoscopic studies and photography of operations, astronomical and photoelastic studies, Schlieren photography and a number of other applications. The final chapter treats the important subject of evaluation of the photograph.

The book would have its greatest appeal to the general reader. It is confined to known practices, and is devoted almost entirely to German equipment. It is well illustrated.—*Walter Clark*, Kodak Research Laboratories, Rochester 4, N.Y.

New Members

The following members have been added to the Society's rolls since those last published. The designations of grades are the same as those used in the 1950 MEMBERSHIP DIRECTORY.

Honorary (**H**) Fellow (**F**) Active (**M**) Associate (**A**) Student (**S**)

Angwin, Bruce S., Regional Sales Manager, Equipment Tubes, General Electric Co., Electronics Div. **Mail:** 238 North Frederic St., Burbank, Calif. (**A**)

Avil, Gordon, Free-lance Motion Picture Cameraman. **Mail:** 13809 Weddington St., Van Nuys, Calif. (**A**)

Baldridge, Claude C., Motion Picture Supervisor, U.S. Air Force, Edwards Air Force Base, Edwards, Calif. (**A**)

Bisno, Lou, Production Assistant, Snader Telescriptions Corp. **Mail:** 530 North Frederic St., Burbank, Calif. (**M**)

Bridge, Harry P., University of Maine. **Mail:** 109 Commercial St., Boothbay Harbor, Me. (**S**)

Bryant, Harry L., Recording Engineer, Radio Recorders. **Mail:** 4350 Chevy Chase Dr., La Canada, Calif. (**M**)

Buxbaum, Morton L., New Inst. for Film and Television. **Mail:** 357 Milford St., Brooklyn 8, N.Y. (**S**)

Cain, Donald G., University of Minnesota. **Mail:** 5125 South Washburn, Minneapolis 10, Minn. (**S**)

Chaikofsky, Samuel, New Inst. of Film and Television. **Mail:** 2504 Bronx Park East, New York 67, N.Y. (**S**)

Crevenna, Alfredo B., Writer and Motion Picture Director. Ultramar Films. **Mail:** Parque Melchor Ocampo 28, Dep. 5, Mexico, D.F., Mexico. (**A**)

Curtis, Harold K., Foreman, Release Dept., Paramount Pictures Laboratory. **Mail:** 9021 Dicks St., Los Angeles 46, Calif. (**A**)

Dixon, Herbert W., Television Motion Picture Production, John Sutherland Productions, Inc. **Mail:** 11280 Brookhaven Ave., Los Angeles, Calif. (**M**)

Downey, C. E., Television Engineer, KGO-TV. **Mail:** 119 Villanova Dr., Oakland 11, Calif. (**A**)

Eckes, John D., Jr., Supervisor, Camera Dept., United Productions of America. **Mail:** 362 South Myers St., Burbank, Calif. (**A**)

Elliott, Richard S., Senior Photographer, Motion Picture Div., University of Southern California at Los Angeles. **Mail:** 550¾ South Barrington, Los Angeles 49, Calif. (**A**)

Fallis, Marne F., Projectionist, United Productions of America. **Mail:** 156 South Pacific Ave., Glendale 4, Calif. (**A**)

Freeman, Howard E., Owner, H. E. Freeman Co. **Mail:** 4517 Sepulveda Blvd., Sherman Oaks, Calif. (**A**)

Gancie, Joseph J., School of Radio Technique, Inc. **Mail:** 108 Central Ave., Brooklyn 6, N.Y. (**S**)

Glennan, Gordon R., General Manager, Sound Services, Inc. **Mail:** 802 North Martel Ave., Hollywood 46, Calif. (**M**)

Governor, Frank, School of Radio Technique, Inc. **Mail:** 74 Irving Pl., New York, N.Y. (**S**)

Graff, Earl F., Assistant Manager, Pembrex Theatre Supply Corp. **Mail:** 10540 Pangborn Ave., Downey, Calif. (**A**)

Hall, Robert D., Manufacturer, Projection screens and equipment, Commercial Picture Equipment, Inc. **Mail:** 1567 West Homer St., Chicago, Ill. (**M**)

Harris, Sgt. William J., AF 13234996, Motion Picture Sound Recording and Projection, U.S. Air Force. **Mail:** 731 Franklin Cir., Portsmouth, Va. (**A**)

Hoffman, Wendell L., Manager, Photographic Laboratory, University of Nebraska. **Mail:** 5019 Walker Ave., Lincoln, Nebr. (**A**)

Jacobs, Harry N., Television Engineer, KGO-TV. **Mail:** 1600 Merced St., Richmond, Calif. (**A**)

Jones, Merwin C., Television Engineer, KGO-TV. **Mail:** 270 El Bonito Way, Millbrae, Calif. (**A**)

Kelly, Peter J., Motion Picture Cameraman (Documentary), Shell Film Unit. **Mail:** White Barn Hotel, Cuddington, North Northwich, Cheshire, England. (**A**)

Kenik, Marvin, SRT Television Studios. **Mail:** 348 E. 19 St., New York 3, (**S**)

Koshlaychuck, William E., Supervising Editor, Commercial Dept., Telenews, Inc. **Mail:** 6817 Owls Head Ct., Brooklyn, N.Y. (**M**)

Lehman, John Francis, Syracuse University. **Mail:** 115 College Pl., Syracuse 10, N.Y. (**S**)

Le Vino, Richard B., Chief, Televisual Equipment Section, Signal Corps Engineering Laboratories, Coles Signal Laboratory. **Mail:** 36 Riverside Ave., Red Bank, N.J. (**M**)

Lunt, Mack G., Cinetechnician, Pembrex Theatre Supply Corp. **Mail:** 636 Dittmaiz Dr., Whittier, Calif. (**A**)

McLaren, Norman, Animation Producer, National Film Board of Canada. **Mail:** 520 St. Patrick St., Ottawa, Ont., Canada. **(A)**

Micllef, Edgard Roger, School of Radio Technique, Inc. **Mail:** 492 Third St., Brooklyn 15, N.Y. **(S)**

Morgan, Kenneth, Physicist, Interchemical Corp. **Mail:** 45–14 — 30 Ave., Long Island City 3, L.I., N.Y. **(M)**

Morrison, Arnold, Self-employed, Film Producer. **Mail:** 68 Fifth Ave., New York, N.Y. **(M)**

Mueller, Arthur C., Design Engineer, Bell & Howell Co. **Mail:** 1637 Sherman Pl., Des Plaines, Ill. **(A)**

Mullin, John T., Electronics Development Engineer, Bing Crosby Enterprises, Inc. **Mail:** 1351 Kelton Ave., Los Angeles 24, Calif. **(A)**

Nicholson, Donald S., Technical Assistant to Director of Studio Operations, Technicolor Motion Picture Corp. **Mail:** 1216 Oak Circle Dr., Glendale 8, Calif. **(A)**

Nopper, C. G., Chief Engineer, WMAR-TV. **Mail:** 31 Dunkirk Rd., Baltimore 12, Md. **(M)**

Peterson, Richard S., School of Radio Technique, Inc. **Mail:** 572 Amsterdam Ave., New York, N.Y. **(S)**

Petrushansky, Yevsie S., Free-lance Producer-Director. **Mail:** 5222 North 11 St., Philadelphia, Pa. **(M)**

Pruitt, Jerome, School of Radio Technique, Inc. **Mail:** 251 W. 111 St., Apt. 4B, New York 26, N.Y. **(S)**

Read, George W., Electronic Design Engineer, Westrex Corp. **Mail:** 941 East Dryden, Glendale 7, Calif. **(M)**

Rice, John G., Electronic Engineer (Television), Signal Corps Engineering Laboratories. **Mail:** 4 William St., Red Bank, N.J. **(M)**

Rogers, John M., Laboratory Technician, Commonwealth Film Laboratories, Pty., Ltd., 60 Wilton St., Sydney, N.S.W., Australia. **(A)**

Savage, Alfred D., Projectionist, Instructor on Theater Television, Fred Wehrenberg Theatre Circuit and Local 143. **Mail:** 215 Eichelberger, St. Louis 11, Mo. **(A)**

Sayers, Eric Russell, Executive Vice-President, Agency Consultants, Inc. **Mail:** 639 E. 11 St., New York 9, N.Y. **(A)**

Seligman, Steven M., Film Editor, CBS-TV. **Mail:** 40 W. 72 St., New York, N.Y. **(A)**

Stubbs, William S., Photographer, Air Reduction Sales Co. **Mail:** 556 Stratford Rd., Union, N.J. **(A)**

Switzer, Israel, University of Alberta. **Mail:** 10542–83 Ave., Edmonton, Alberta, Canada. **(S)**

Talamini, Arthur, Jr., Television Engineer, A. B. Du Mont Laboratories, Inc., 1000 Main Ave., Clifton, N.J. **(M)**

Thiebaux, M. L., Design Engineer, North American Aviation. **Mail:** 14869 Janine Dr., Whittier, Calif. **(A)**

Tremblay, Louis R., Self-employed, High-Speed Motion Pictures. **Mail:** 17146 Warrington Dr., Detroit 21, Mich. **(A)**

Waddington, Lester E., Radio-Television Director, Miles Laboratories, Inc. **Mail:** 820 Edwardsburg Ave., Elkhart, Ind. **(M)**

Wagg, Alfred, Self-employed, Cameraman, Journalist and Film Director-Producer. **Mail:** 3565 Martha Custis Dr., Alexandria, Va. **(M)**

Walther, E. L., Sound Engineer, RCA Photophone of Australia, Pty., Ltd., 221 Elizabeth St., Sydney, N.S.W., Australia. **(A)**

Ward, H. Connell, Engineer, RCA Victor Div., 1560 North Vine St., Hollywood, Calif. **(A)**

Winchester, Ted, Assistant Head, Photographic Dept., RKO. **Mail:** 1704 South Canfield Ave., Los Angeles 34, Calif. **(A)**

CHANGES IN GRADE

Conant, Russell W., Technicolor Motion Picture Corp., 6311 Romaine St., Hollywood 38, Calif. **(A)** to **(M)**

Culley, Ray, President, Cinecraft Productions, Inc. **Mail:** 21271 Morewood Pkwy., Rocky River 16, Ohio. **(A)** to **(M)**

Dickely, F. C., Sales Engineer, Altec Service Corp., 2211 Woodward, Detroit, Mich. **(A)** to **(M)**

Dickert, James E., Motion Picture Recording and Production, Wilding Picture Productions, Inc. **Mail:** 642 Ash St., Winnetka, Ill. **(A)** to **(M)**

Eglinton, William, Head, Photographic Dept., RKO Radio Pictures, 780 North Gower St., Hollywood 38, Calif. **(A)** to **(M)**

Fermaglich, Charles, Motion Picture Producer, President, Empire Studios. **Mail:** 618 Medical Arts Bldg., Houston, Tex. **(A)** to **(M)**

Fulwider, Robert W., Patent Lawyer, Partner, Fulwider Mattingly. **Mail:** 5225 Wilshire Blvd., Los Angeles 36, Calif. **(A)** to **(M)**

Gaw, Ernest D., Service Inspector, Inter-State Circuit, Inc. **Mail:** 830 Cherokee Trace, Grand Prairie, Tex. **(A)** to **(M)**

Hart, William J., Motion Picture Sound Technician, Wright-Patterson Air Force Base. **Mail:** 970 West Main St., Wilmington, Ohio. (A) to (M)

Hedden, William D., Laboratory Superintendent, The Calvin Co., 1105 Truman Rd., Kansas City, Mo. (A) to (M)

Landau, Alfred, Motion Picture Engineer, Columbia Pictures Corp. **Mail:** 344 Spalding Dr., Beverly Hills, Calif. (A) to (M)

LaRue, M. W., Jr., Mechanical Engineer, Bell & Howell Co. **Mail:** 1225 Grove Ave., Park Ridge, Ill. (A) to (M)

Lowe, L. W., Self-employed, Producer, Lecturer. **Mail:** Box 89, Paola, Kan. (A) to (M)

Macon, N. Donald, Industrial Motion Picture Producer, Owner, Texas Industrial Film Co. **Mail:** 919 M & M Bldg., Houston, Tex. (A) to (M)

Martin, Mahlon H., Jr., Owner, Audio Visual Center. **Mail:** 1118 Lincoln Way, East, Massillon, Ohio. (A) to (M)

Peck, Charles D., Manager-Owner, Southwest Theatre Equipment Co., 118½ West Douglas Ave., Wichita 1, Kan. (A) to (M)

Pope, Lucian E., Purchasing Agent, Fox Midwest Amusement Corp. **Mail:** 2216 W. 49 St. Ter., Kansas City, Kan. (A) to (M)

Sandback, Irving C., Optical Design Engineer, Bell & Howell Co. **Mail:** 3711 West Pratt, Lincolnwood, Ill. (A) to (M)

Souther, Howard T., Manager, Speaker Division, Electro-Voice, Inc., Buchanan, Mich. (A) to (M)

Meetings

The Central Section of the SMPTE has scheduled two papers for its meeting at the Bell & Howell Co., 7100 McCormick Blvd., Chicago, on March 27. Bruno G. Staffen, development engineer of the Jensen Manufacturing Co., will describe a new low-cost theater speaker system, and there will be a description of the new Bell & Howell magnetic and optical 16mm sound projector by J. B. Weber, H. H. Brauer, F. J. Schussler and M. G. Townsley. C. E. Heppberger is Central Section Chairman, and John S. Powers is Program Chairman.

71st Semiannual Convention of the SMPTE, April 21–25, The Drake, Chicago

Other Societies

I.R.E. National Convention, Radio Engineering Show, Mar. 3–6, Hotel Waldorf-Astoria and Grand Central Palace, New York

National Electrical Manufacturers Association, Mar. 10–13, Edgewater Beach Hotel, Chicago, Ill.

American Physical Society, Mar. 20–22, Columbus, Ohio

Optical Society of America, Mar. 20–22, Hotel Statler, New York

American Physical Society, May 1–3, Washington, D.C.

Acoustical Society of America, May 8–10, New York

American Institute of Electrical Engineers, Summer General Meeting, June 23–27, Hotel Nicollet, Minneapolis, Minn.

American Physical Society, June 30–July 3, Denver, Colo.

Photographic Society of America, Annual Convention, Aug. 12–16, Hotel New Yorker, New York

American Institute of Electrical Engineers, Pacific General Meeting, Aug. 19–22, Hotel Westward Ho, Phoenix, Ariz.

Illuminating Engineering Society, National Technical Conference, Aug. 27–30, Washington, D.C.

SMPTE Officers and Committees: The roster of Society Officers and the Committee Chairmen and Members were published in the April 1951 *Journal*.

New Products

Further information about these items can be obtained direct from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of these items does not constitute endorsement of the products.

A playback recorder that puts 60 min of speech or music on a vinylite disc $4\frac{3}{4}$ in. in diameter, operating at 16 rpm and at a pitch of 448 lines/in. is the "Wagner-16" MicroDisc Recorder, Model P16-450. The portable carrying case, weighing 28 lb complete, contains the complete mechanism and recording head, amplifier and power supply, playback pickup and loudspeaker for recording and playing back.

Although it is recommended that the prime application for MicroDiscs is in reference, closed circuit and conference work, the manufacturer claims that fidelity of reproduction is also excellent for musical material. The disc drive uses no turntable, which, it is said, eliminates all flutter and wow, enabling extended bass response. The design of the feed screw affords accuracy of pitch, it is said, as great as that found in the most professional recorders. The "Wagner-16" also features "spiralling," and a "magic-eye" volume-level indicator is an integral part of the equipment. A recording time reference scale operates automatically. Two input receptacles, switch selected, are provided, one for the microphone and the other for "bridging." The equipment operates from 115 volts, 60-cycle a-c, with 50-cycle optional.

MicroDisc blanks are $2.50 for a package of 12. The complete MicroDisc recorder includes all styli (sapphire), microphone, PM loudspeaker, extra input plugs and instruction manual, at a cost of $295 from the Audio & Video Products Corp., 730 Fifth Ave., New York 19, N.Y.

Film Research Associates, located at 150 E. 52 St., New York 22, N.Y. publishes and distributes seven guides to available training aids. Listed are the sources of functional films for meetings, conferences, classes or study groups, with alphabetically arranged descriptions of type, running time and use. Procedures are recommended for effectively using audio-visual methods. The guides are priced separately at $1.00 to $2.00 and the complete set of seven publications is $9.00.

American Standards form the technical foundation for motion pictures around the world. All current standards were listed by subject and by number in the *Journal* Index 1946–1950. Reprint copies of this list, which includes all previous *Journal* references to each standard, are available from Society Headquarters without charge.

Complete sets of all sixty current standards in a heavy three-post binder with the index are $13.50, plus 3% sales tax for purchases within New York City, and are available from Society Headquarters. Single copies of any particular standard must be ordered from the American Standards Association, 70 East 45th St., New York 17, N.Y.

Image Gradation, Graininess and Sharpness in Television and Motion Picture Systems

Part II : The Grain Structure of Motion Picture Images—An Analysis of Deviations and Fluctuations of the Sample Number

By OTTO H. SCHADE

CONTENTS

Presented by Otto H. Schade, Tube Dept., Radio Corporation of America, Harrison, N.J., in part on April 20, 1950, at the Society's Atlantic Coast Section Meeting at New York, and on May 3, 1951, at the Society's Convention at New York. Portions of this paper have been made available to the Subcommittee on Distribution Facilities, Theater Television Committee of the SMPTE, in the form of three reports: (1) "Random Fluctuations in Television and Motion Pictures," June 7, 1950; (2) "Outline and Results of a Study to Determine Television System Parameters Providing an Image Sharpness Equivalent to a 35-Millimeter Motion Picture Process," May 15, 1951; (3) "Theater Television Transmission Channel: Choice of Performance Factors," May 31, 1951.

Note: Part I of this paper, "Image structure and transfer characteristics," was published in this *Journal* in February 1951, pp. 137–171.

SYMBOLS

Note: Peak values are designated by a peak sign over a symbol, $\hat{B}$; and average or mean values by a horizontal bar, $\bar{n}$.

a Area of sampling aperture
Δa Incremental portion of a
$\bar{a}$ Mean value of response factor $r\bar{\psi}$ in incremental section ΔN
A Frame area
B Luminance
c A constant
D Total density of photographic film; D_1 density of negative film, D_2 density of positive film
D^* Density above base density
E Exposure (unit: meter candle seconds)
f Frequency; $f(x, y)$ a function of x and y
H Horizontal dimension of picture frame
K A constant
l Unit of length
N Line number = number of half-wave lengths of line- or sine-wave patterns per length unit
N_c Limiting resolution
$N_e N_e^*$ $\bar{N}_o$ Equivalent passbands (Eqs. (22) to (28))
$\overline{N_e}$ Equivalent passband of an asymmetric aperture (Eq. (23))
N_{cr} Rated resolving power of film ($r\bar{\psi} \simeq 0.02$)
N_δ Line number indicating aperture diameter (Eq. (19))
n Number of particles or samples inside of sampling area
Δn Deviation from average number $\bar{n}$; $\Delta n = n - \bar{n}$
$[\Delta n]$ Rms value of deviation
r_o Characteristic radius of an aperture
$r\bar{\psi}$ Sine-wave response factor (Eq. (18))
$[R]$ Signal-to-rms-deviation ratio static value in a single image frame (Eq. (13))
$[R]_\tau$ Signal-to-deviation ratio of film transmittance (Figs. 49–52)
$[R]^*$ Signal-to-deviation ratio neglecting lens flare and ambient light
$[R]_{13}$ etc. Signal-to-deviation ratio of a process. The index 1 is used for deviations originating in a negative film process; the index 2 for a positive film process; the index 0 for a process (lens) preceding the negative; the index 3 for a process (lens) following the positive. An index 13 indicates deviations originating in 1 and observed after the processes 2 and 3.
$[R]_o$ Luminance fluctuation ratio, dynamic value (Eq. (47))
s Length of side of square aperture, or storage factor
T_f Frame time
T_s Storage time (Eq. (47))
u A characteristic length unit used in aperture calculations
V Vertical frame dimension
x, y Coordinates, x = coordinate in the direction of scanning
Y Amplitude, intensity
γ Constant gamma
$\dot{\gamma}$ Point gamma, definition in Part I, p. 145. A single index number indicates the process as stated under $[R]_{13}$; a combination index ($\dot{\gamma}_{13}$) indicates the product $\dot{\gamma}_1\dot{\gamma}_2\dot{\gamma}_3$.
δ Characteristic aperture diameter (index system as for $[R]$)
ϵ Base of natural logarithm
τ Transmittance
σ Relative deviation (Eqs. (13) to (17))
ψ Flux
$[\bar{\psi}]$ Rms value of variational (a-c) flux (see Eq. (20))
$\bar{\psi}$ Average (d-c) flux
$\bar{\psi}_0$ Zero "frequency" component of flux (see Eqs. (18) and (21))
$\bar{\psi}_0$ A light bias (see discussion of Eq. (38))

SUMMARY OF PART II

An objective measure of the luminance deviation caused by the random structure in motion picture and television images is developed, based on the distribution and a count of the number of grains or electron "samples" in a specified sampling area. The "effective sampling area" of the various components in photographic or television systems is determined from their response to sine-wave test signals and specified by an equivalent measure N_e. The accuracy of this method is compared with a direct evaluation from the dimensions of the point image or resolving "aperture" for which the geometrical properties are

known. The law of sample distribution at the sources of the deviations in motion picture systems is investigated and methods are developed for computing the relative deviation and the "frequency" spectrum in the entire luminance range of the projected image as modified by successive aperture-response and nonlinear transfer effects. Numerical evaluations of a number of motion picture processes are carried out and a discussion is included of optimum conditions for video recording and possibilities for improvements.

Part II is limited to a treatment of aperture-response theory as applied to the evaluation of the relative deviation in motion picture processes. Part III, to be published later, will treat the raster effect, the apertures and the relative deviation ("noise"-to-signal ratio) in television systems, followed by an interpretation of graininess which includes the process of vision. The aperture theory and use of the measure N_e will be developed further in Part IV which will deal specifically with methods and measurements for evaluating resolution, definition and sharpness of images.

A. DYNAMIC FLUCTUATIONS AND STATIC DEVIATIONS

Continuity of contours and uniformity of tone values in an image are in reality illusions created by a limited perception of fine detail, an inability to count or resolve the individual "samples" of energy or matter forming the image. This limitation can usually be removed when a small area a is inspected under high magnification. Suppose the number n of samples arriving in this "sampling area" or passing through a "sampling aperture" placed over a live image is counted during a time unit. The number n obtained in various counts will be found to *fluctuate* around an average value $\bar{n}$ which does not change when the sampling area is moved to different locations in a larger area representing a uniform intensity. The fluctuations in different positions of the area a, however, are generally found to be nonsynchronous. In a "live image" from a lens, television tube or motion picture film, these fluctuations in the number of light samples are fluctuations of luminance which give the impression of a moving granular structure.

In most reproduction processes the light samples in a live image are converted, accumulated, and stored in special image surfaces during a given (exposure) time in the form, for example, of silver grains or electron charges. Such an *image frame* is, therefore, a static record of the number and distribution of effective samples collected during the exposure time. A single "frame" does not show dynamic fluctuations but exhibits static *deviations* in the number of samples between sampling areas.

The *static deviation* in a sample arrangement representing a constant density can be evaluated statistically by counting the samples (grains, electrons) in a sampling area a which is moved to various positions, determining the mean value $\bar{n}$ of the readings, and tabulating the deviations in number Δn from the mean value $\bar{n}$. The rms value $[\Delta n]$ of the deviations is known as the standard deviation. The ratio of the standard deviation to the mean value is the *relative deviation* σ; its reciprocal is the "*signal-to-deviation*" *ratio* $[R]$. The two ratios are defined by the equation:

$$\sigma = 1/[R] = [\Delta n]/\bar{n} \qquad (13)$$

When the samples in an image frame are distributed with uniform probability independently of one another, and when the area occupied by a sample is small compared to a, the average number of samples counted in a sampling aperture of uniform transmittance is proportional to its area a

$$\bar{n} \propto a \tag{14}$$

The rms deviation $[\Delta n]$ is found to follow the law

$$[\Delta n] = (\bar{n})^{\frac{1}{2}} \tag{15}$$

and the relative deviation (Eq. (13)) for this distribution is, hence,

$$\sigma = (\bar{n})^{-\frac{1}{2}} \tag{16}$$

This relation changes inversely with the square root of the sampling area:

$$\sigma \propto a^{-\frac{1}{2}} \tag{17}$$

A distribution with these characteristics will, henceforth, be referred to as a *random* distribution. This distribution can be verified by testing the validity of Eqs. (15), (16) and (17) by a sampling process. A grain structure containing samples of several sizes has a random distribution when the distribution for each sample size is random as specified above. The definition holds also for a structure which can be considered as a linear superimposition of a number of sample layers, each having a random distribution.

B. PHYSICAL SAMPLING APERTURES FOR RANDOM AND CONTINUOUS SAMPLING PROCESSES

The random step-wise selection of sampling positions in static-deviation measurements (discussed in the Appendix to this Part) can be replaced by a continuous displacement of the sampling aperture. When, for example, the grain structure of an illuminated film of constant density is "scanned" by an aperture, the light flux passing through the sampling aperture into a phototube is a relative measure of the grain number n and causes a current, fluctuating in amplitude around an average value. The total current may be shown by an oscillograph or recorded by a microphotometer; its average value (signal) as well as the rms deviation (a-c component) can be measured directly by suitable current meters.

In both step-wise or continuous deviation measurements the total flux, i.e., the number of samples integrated or "counted" within a sampling aperture of *uniform transmittance*, is proportional to the *area* of the aperture. The aperture *shape* is, in principle, unimportant (barring diffraction or diffusion) because any odd-shaped aperture of uniform transmittance can be assembled from a number (Z) of small apertures Δa of equal size, which may be arranged in any desired shape.† When the grain distribution is random, as specified above, there is no correlation or preferred sequence of grain occurrences when the grain pattern is sampled or scanned. A round sampling aperture, however, is advantageous because it reduces undesired optical effects (diffraction) to a minimum.

In contrast to the above, the shape of a scanning aperture analyzing or *forming pictorial images* or images of test charts can be of importance, because these images may consist of sample arrangements with definite preferred locations (straight or curved contours), according to the subject material. Sampling apertures with circular symmetry are preferred for simultaneous imaging and are used also as scanning apertures in television systems.

Comparison of a graph of sample readings taken at random from a grain pattern with a microphotometer trace shows that there is a considerable difference in the *sequence* of values ob-

† The relative deviation for an area $a = Z\Delta a$ is simply $\sigma = \sigma_1/\sqrt{Z}$, with σ_1 = relative deviation of Δa.

tained by random step-wise sampling as compared to the conditioned sequence of amplitudes in a waveform obtained by a continuous displacement of the same sampling aperture over the same grain pattern.

The average value (d-c signal) of the graph or waveform and the rms deviation, however, are unchanged when a sufficient number of sampling points has been taken. The signal-to-deviation ratio [R] can, hence, be determined accurately by random or continuous sampling with an aperture.

C. METHOD OF EVALUATING THE EFFECTIVE SAMPLING AREA OF AN UNKNOWN APERTURE

The standard deviation has obviously no meaning when the size of the sampling aperture remains unknown or unspecified. When deviations are imaged, i.e., transferred, through an imaging system, the components (lens, film) of the system cause an integration of samples within the area of their point image (star image). The point image which has been identified as the "resolving aperture" of the device, represents, therefore, the sampling aperture of the device referred to the image plane. The equivalent area a of this aperture must, hence, be known for all system components in order to evaluate signal-to-deviation ratios.

It is difficult and in many cases impossible to measure the sampling aperture of a system component directly, but it is relatively simple to analyze the aperture effect in images made of suitable test objects. According to a Fourier theorem the complex waveform obtained by the scanning of a random structure can be broken down into a continuous spectrum of constant-amplitude sine-wave components which, for this purpose, can be regarded as having equal amplitudes and random phase relation. This sine-wave spectrum does not extend to infinity, but the sine-wave amplitudes may be assumed as constant over a wide range of wavelengths usually extending far beyond the limiting resolution of the first sampling aperture. It is thus expected that the integrating effect of a sampling aperture on fluctuations can be synthesized from the aperture effect on single sine-wave components determined with a series of test patterns, each representing a sinusoidal flux pattern of one constant optical sine-wave length in the image field. When the shape and passband of the sine-wave response characteristic of the unknown aperture are compared with those of known aperture types (round, cosine squared, exponential, etc.), an exact or an equivalent aperture area can be established for the particular device or for an entire process. It appears advisable at this point to define units and terms, particularly the meaning of optical sine waves, line numbers, and passbands.

1. Units and Terminology

The conventional optical test pattern consists of groups of sharply defined adjacent bars, alternately black and white and of equal width. The width of the bars decreases from group to group. These patterns are optical *square-wave flux patterns* having decreasing square-wave lengths. Variable-density recordings of electrical sine-wave signals on the sound track of a motion-picture film accordingly represent optical *sine-wave flux patterns* (see Fig. 40). Optical patterns always have and must have two dimensions to be useful for measurements with two-dimensional apertures. For a study of the sine-wave response of an aperture in one direction, the test pattern must

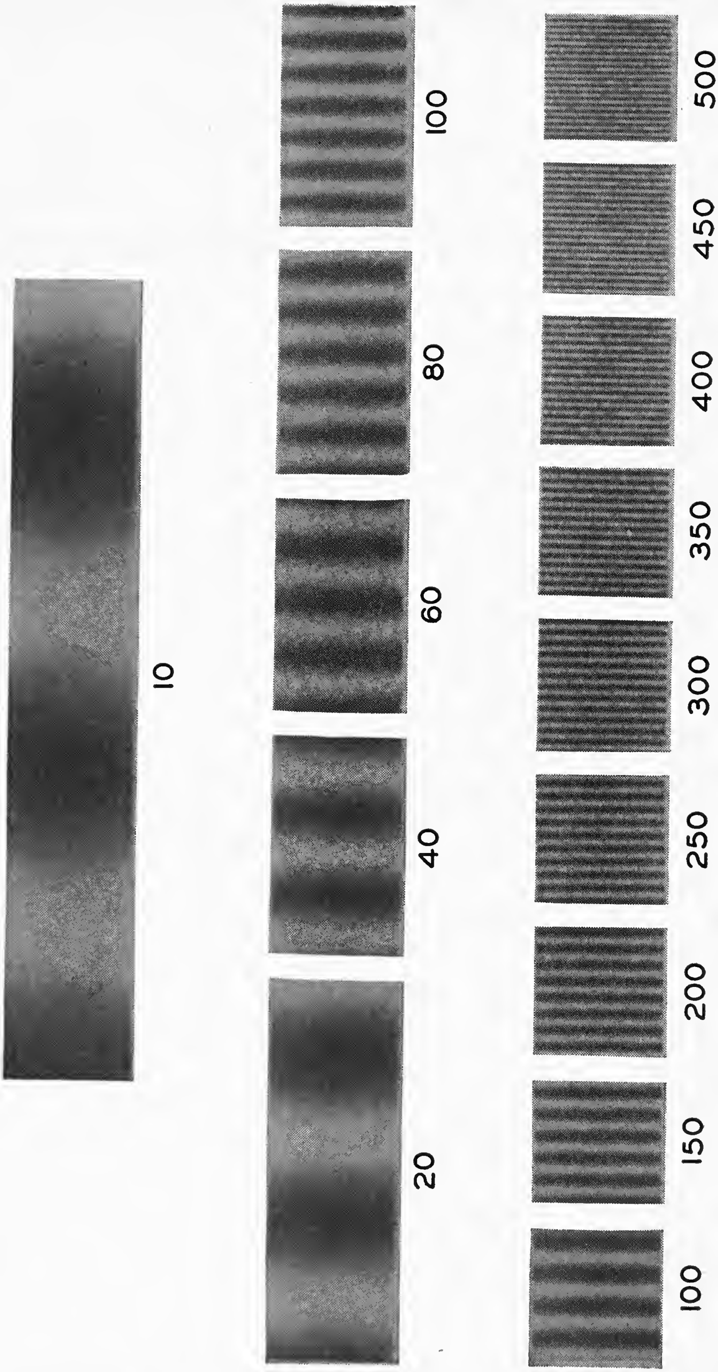


Fig. 40. Optical sine-wave test pattern.

give a flux distribution varying sinusoidally in one direction of the field but remain uniform in the perpendicular direction, appearing to the eye as a series of parallel dark and light bands or lines (Fig. 40). When imaged by an aperture (lens, film) or scanned by an aperture (perpendicular to the lines) the reproduced flux pattern or the flux signal from the aperture is again a pure sine-wave pattern or signal, but with reduced amplitude which may be computed or measured as a function of the sine-wave length in the optical test pattern. When measuring optical wave patterns the unit is obviously a length. Its reciprocal in analogy with electrical terms, is an "optical frequency" stating the number of waves per length unit (not time). In television terminology one full wave in the test field consists of two half-waves, the positive half-wave being identified as a light "line" and the negative half-wave as a dark "line," thus leading to the definition: *the line number N specifies the number of half-waves per reference length.* The television unit will be used throughout this paper unless stated otherwise. The television unit is smaller by a factor of two than the photographic unit which identifies one line with one complete wavelength.†

The sine-wave flux response is specified in relative units by the *sine-wave flux response factor* $r\tilde{\psi}$, defined as the ratio of the sinusoidal aperture flux $\tilde{\psi}_N$ at a line number N to the sinusoidal aperture flux $\tilde{\psi}_0$ at a line number N approaching zero as a limit.

$$r\tilde{\psi}_N = \tilde{\psi}_N/\tilde{\psi}_0 \qquad (18)$$

The response factor $r\tilde{\psi}$ is single valued and *independent of the test-pattern contrast* provided waveform distortion by nonlinear transfer characteristics is avoided by restricting the "signal" amplitudes (contrast) from the test pattern to appropriate values. The *optical passband* of the aperture is the range of line numbers from $N = 0$ to $N = N_c$ in which the aperture response $r\tilde{\psi}$ decreases from unity to zero. It is emphasized that, strictly speaking, this passband describes the aperture response in one direction only, the direction of scanning. Apertures of circular symmetry have but one response characteristic and passband for all directions, while asymmetric apertures (squares, slits, etc.) have many response characteristics and optical passbands depending on the aperture orientation relative to the direction of displacement. Description of an asymmetric aperture by its aperture response requires at least two characteristic passbands (vertical and horizontal) which for some purposes can be replaced by the passband of an aperture with circular symmetry and equivalent area a (see Sec. 3 below).

2. Aperture Response Characteristics

The "aperture response" of optical devices is usually observed on square-wave line patterns. The sine-wave response can be derived from the square-wave flux response or may be measured directly as will be described in Part IV which will deal specifically with the subjects of resolution and aperture response characteristics and a new system of rating based on the measure of equivalence developed in the following section. The sine-wave response factor $r_{\tilde{\psi}}$ has been computed for various sampling apertures and is shown in Figs. 41 to 46a.

The line number for these aperture types is expressed in relative units N/N_δ which refer to a characteristic aperture diameter

$$\delta = l/N_\delta \qquad (19)$$

where l = unit of length (l = 1 milli-

† When the number of lines in a background other than black or white is specified, the photographic definition of counting only one of the two distinct lines in the pattern appears less descriptive than the television definition which applies to all cases.

meter, or $l = V$ = vertical dimension of frame). The line number N_δ specifies the condition at which the length of one half-wave in an optical sine-wave pattern equals the characteristic aperture diameter δ. Sharply defined apertures have response characteristics (Figs. 41 and 42) exhibiting an oscillatory decrease of the response factor with several zero values and 180° phase change at every zero value, indicated in the drawings by a change of direction.

Grain structures such as in photographic film or kinescope phosphors do not, in general, form an infinitesimal image of a mathematical point of light and, therefore, have an aperture effect. When a grain layer of finite thickness is

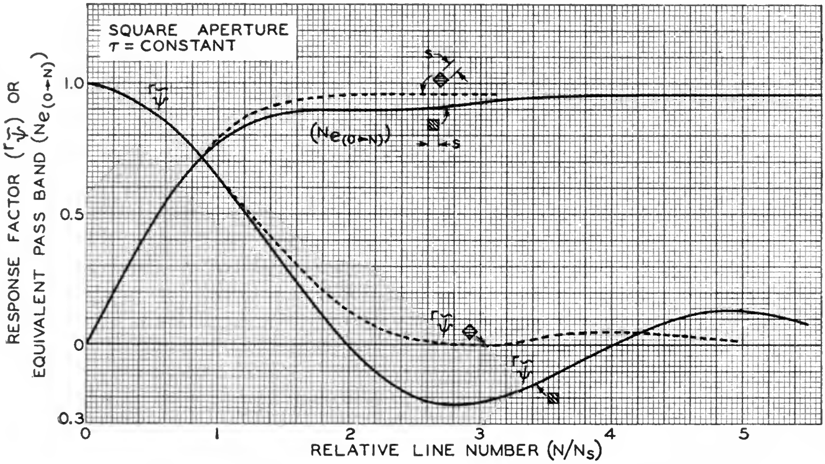


Fig. 41. Sine-wave response characteristics of square aperture.

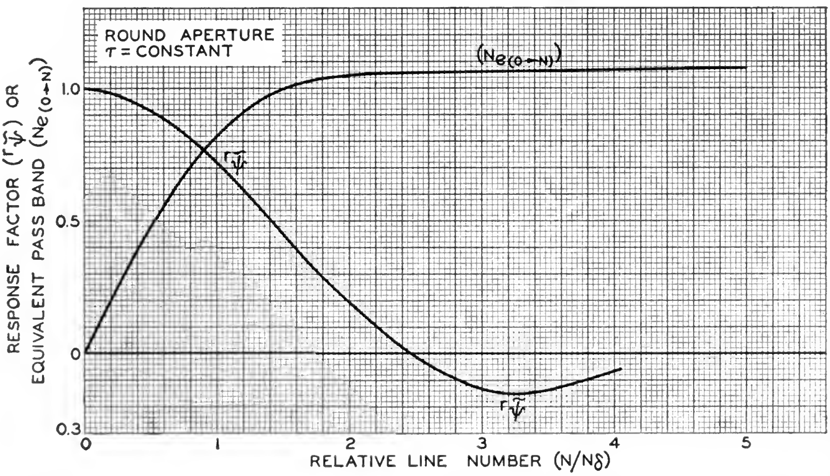


Fig. 42. Sine-wave response characteristics of round aperture (τ = const.).

exposed to an infinitesimal pencil of light (or electrons), diffraction, diffusion, and progressive absorption of light cause an exponential spreading of light in the grain layer, leading to the hypothesis that the point image of the structure has the form of a round "aperture" with exponential transmittance $\tau = \epsilon^{-r/r_o}$. The sine-wave response computed for this theoretical equivalent, is shown in Fig. 46a in relative units N/N_δ for a diameter $\delta = 6r_o$.

Photographic film is exposed to light twice, once during exposure, and then again upon projection of the developed image. The main aperture effect of its grain structure occurs during exposure in the *undeveloped semitransparent*

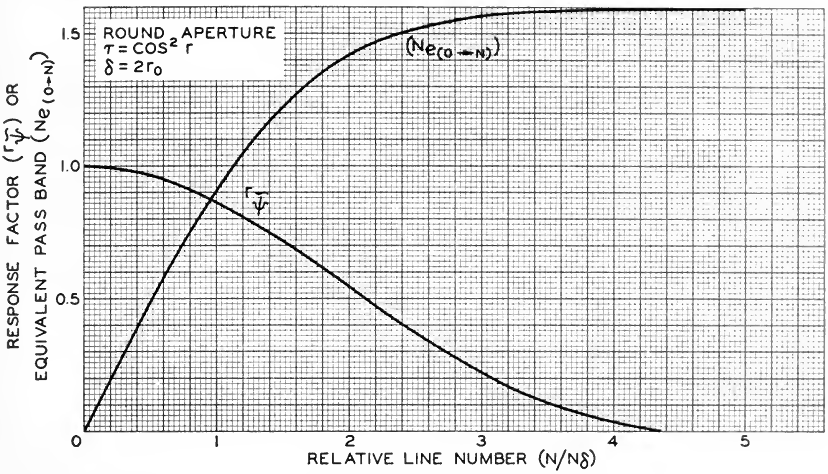


Fig. 43. Sine-wave response characteristics of round aperture ($\tau = \cos^2 r$).

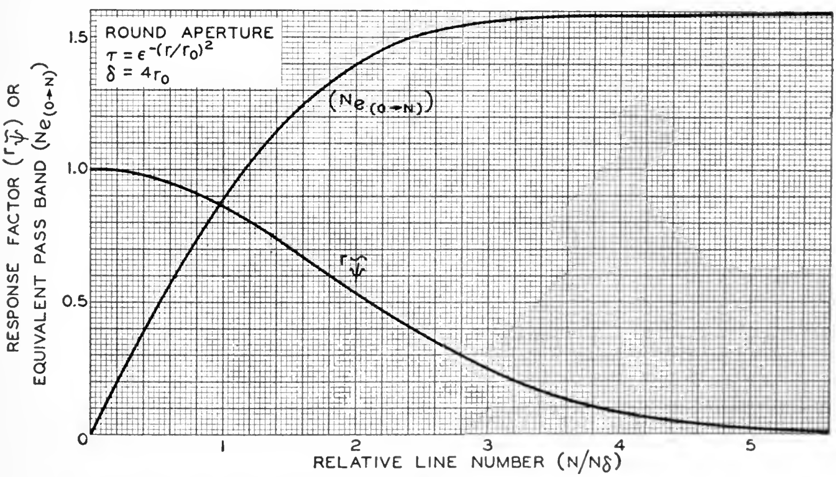


Fig. 44. Sine-wave response characteristics of round aperture ($\tau = \epsilon^{-(r/r_o)^2}$).

state of the structure. The second aperture effect occurs in the transmission of light through the *developed* grain structure in printing or projection processes and is of much smaller magnitude because of the high absorption of light in the "black" silver grain structure. The total aperture effect of photographic film is, therefore, caused by large and small exponential aperture in cascade, dominated by the first aperture effect during exposure. It is thus found that the sine-wave response measured with an electronic microphotometer[1] on test patterns photographed on a variety of films, or optically projected onto kinescope phosphors with various grain sizes, mixtures and thicknesses, is closely

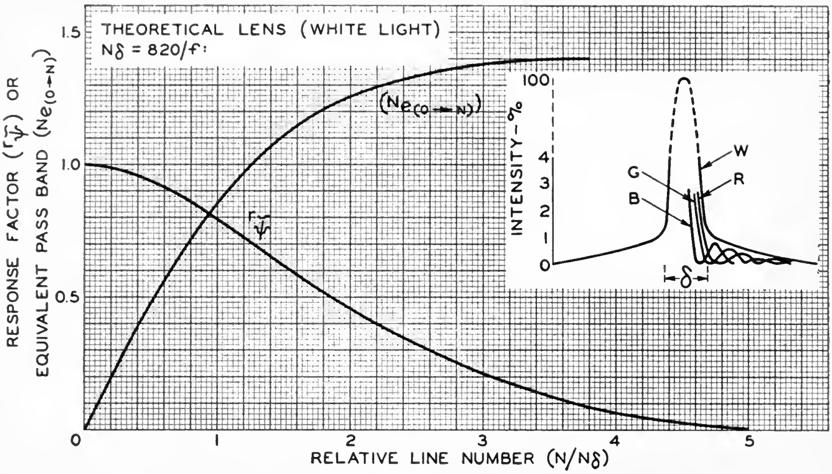


Fig. 45. Sine-wave response characteristics of theoretical lens (white light).

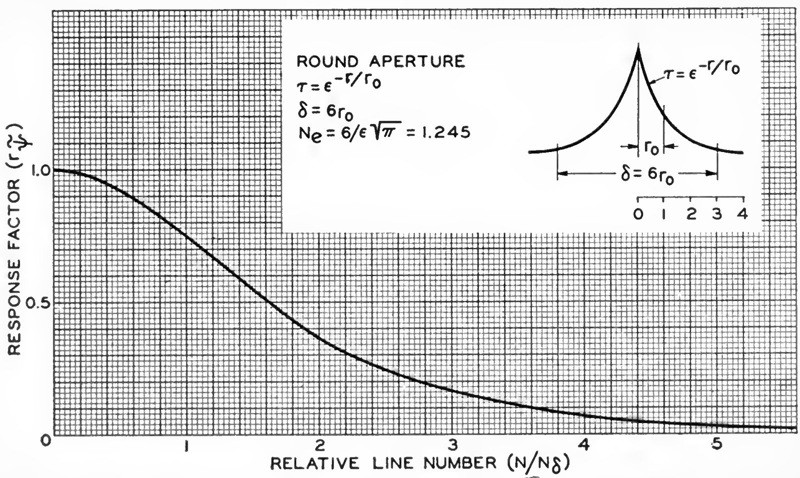


Fig. 46a. Sine-wave response characteristics of mathematical equivalent aperture of grain structures.

represented by the normalized response characteristic Fig. 46b. Exposures representing large signals may lead to waveform distortion which depends on the linearity of the transfer characteristic of the process. These effects can be determined separately by the same methods used in electron-tube evaluations. The rated resolving power N_{cr} of film is found to correspond to a response factor r_{ψ} of roughly 2%. For want of a better reference value, the rated resolving power N_{cr} has been chosen as the reference unit. Comparison of the theoretical and measured characteristics (Figs. 46a and b) shows them to be almost perfect duplicates when N_{cr} is placed at $N/N_{\delta} = 5.17$ in Fig. 46a. It is emphasized that the sine-wave response characteristic of a grain structure is not a measure of its particle size or its granularity and is single-valued in a linear system. Small signals, therefore, should be used when photographic film is measured as pointed out above.

The sine-wave response characteristic of a number of aperture processes in cascade can be computed accurately. *The overall response factor at any given line number N is the product of the response factors of the system components at that line number.* The use of sine-wave test patterns avoids the indirect quadratic addition of line numbers required for cascading square-wave characteristics[1] because, unlike the square-wave flux response which contains harmonic frequencies, the sine-wave flux response retains a pure sine-wave form throughout the system.

3. Evaluation of an Equivalent Passband N_e and a Characteristic Aperture Dimension From the Sine-Wave Spectrum

The sine-wave components in a source of deviations, such as an illuminated random grain structure, may be determined by a Fourier analysis of the complex waveform obtained by scanning the source with an infinitesimal aperture. The amplitude and flux of the various sine-wave components can be considered alike and constant, the components filling a continuous spectrum up to a very high line number, as illustrated by Fig. 47a. Integration of random deviations by a scanning aperture of finite

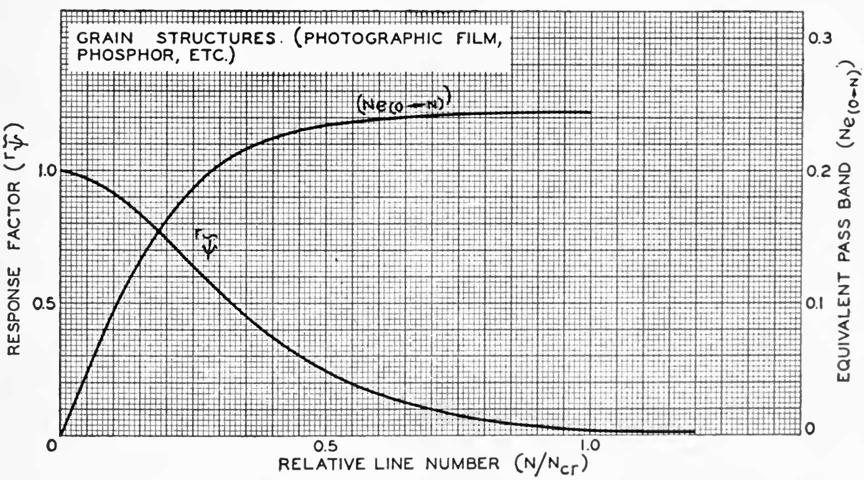


Fig. 46b. Sine-wave response characteristic structures of grain structures (measured).

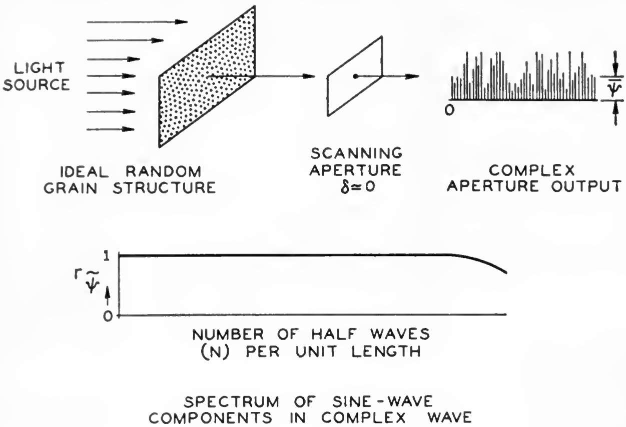


Fig. 47a. Fourier components of ideal random grain structure.

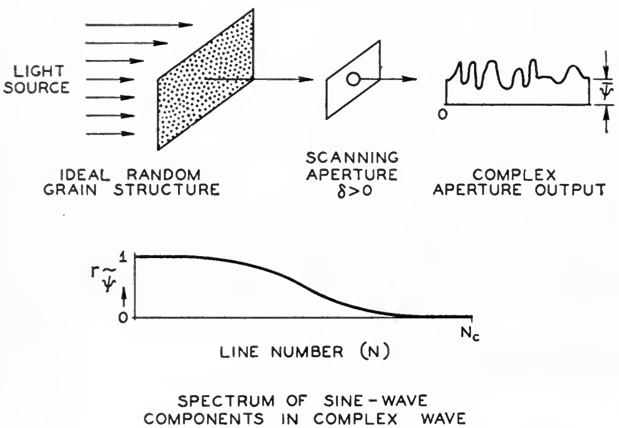


Fig. 47b. Fourier components of random grain structure after an aperture process.

size results in a distribution of flux components and a limited sine-wave spectrum of the type shown in Fig. 47b.

The relative deviation resulting from the scanning of an ideal random structure with an aperture is related to the total response of the aperture by the equation

$$\sigma = [\tilde{\Psi}]/\bar{\Psi} = [{}_0\int^\infty \tilde{\Psi}^2{}_N dN]^{\frac{1}{2}}/\bar{\Psi} \quad (20)$$

The value $\bar{\Psi}$ represents the average value of the total flux; i.e., its d-c component. The value $[\tilde{\Psi}]$ is the rms value of the total (a-c) flux variation given by the $\frac{1}{2}$-power of the integral of squared sine-wave flux deviation components.

When the sine-wave response is normalized according to Eq. (18) so that $\tilde{\Psi}_N = 1$ at $N = 0$, the mean squared flux variation or deviation is expressed by

$$[\tilde{\Psi}]^2 = \tilde{\Psi}_0{}^2{}_0\int^\infty (r\tilde{\Psi})^2{}_N dN \quad (21)$$

where $r\tilde{\Psi}_N$ is the sine-wave response factor and $\tilde{\Psi}_0$ measures the magnitude of the (a-c) flux component passing through the aperture with a line number N approaching zero as stated by Eq. (18). A hypothetical aperture having a con-

stant response ($r\bar{\psi} = 1$) from $N = 0$ to a line number $N_e{}^*$ where the response drops abruptly to zero, would give a mean squared deviation

$$[\bar{\psi}]^2 = \bar{\psi}_0{}^2 N_e{}^*$$

The integral of squared response factors in Eq. (21) may hence be interpreted as a normalized mean squared deviation or an *equivalent passband* of constant amplitude extending to the line number $N_e{}^*$ as defined by

$$N_e{}^* = [\bar{\psi}]^2/\bar{\psi}_0{}^2 = {}_0\!\int^\infty (r\bar{\psi})^2{}_N dN \qquad (22)$$

The measure $N_e{}^*$ has the dimension: length^{-1}. Its reciprocal value expresses an equivalent length or diameter of the aperture *in the scanning direction.* Like the aperture response, $N_e{}^*$ depends, in general, on the aperture orientation relative to the direction x of aperture displacement. Apertures with circular symmetry have a single effective length proportional to their diameter δ and a single value $N_e{}^*$. Elliptical or rectangular apertures can be specified by two values $N_e{}^*{}_{(a)}$ and $N_e{}^*{}_{(b)}$ obtained by orienting their major or minor dimensions (a or b) in the direction of scanning. These two values can be combined into a single value

$$\bar{N}_e{}^* = (N_e{}^*{}_{(a)} N_e{}^*{}_{(b)})^{\frac{1}{2}} \qquad (23)$$

representing an equivalent symmetric aperture.

The direct evaluation of the measure $N_e{}^*$ for an unknown aperture requires a calibrated random grain pattern which must be tested by a harmonic analysis of the complex aperture output. A practical alternative is a synthesis of the sine-wave characteristic from the aperture response to constant amplitude sine-wave patterns of various wavelengths and an evaluation of N_e by Eq. (22). Optical sine-wave patterns consisting of parallel "lines," however, do not duplicate exactly the sine-wave components in a random flux pattern, but rather in a pattern which is random only in the direction x of scanning and uniform in the direction y, perpendicular to the scanning direction. Figure 48a illustrates the difference in cross sections through a random grain structure and a synthetic structure representing an addition of sine-wave test patterns with random phase relation. The differences resulting from scanning a random grain structure or sine-wave test patterns and the suitability of N_e-values, in general, for the purpose of indicating an equivalent aperture area can be determined by a comparison with an equivalent $\bar{N}_o$ based on the *sampling* of a normalized random structure. The various equivalents $N_e{}^*$, N_e and $\bar{N}_o$ can be computed without recourse to response characteristics when the geometrical properties of the aperture are known.

The effective sampling area of an aperture (pictured as a three-dimensional body, the aperture transmittance τ representing height) may be determined by subdividing the aperture into differential columns (see Fig. 48b) with a base area $\Delta a = \Delta x \Delta y$ and constant or varying height representing the transmittance $\tau = f(x, y)$. The relative deviation obtained by taking a large number of samples from a random grain pattern with one differential column is

$$\Delta\sigma = (\tau^2 \bar{n}_o \Delta a)^{\frac{1}{2}}/\tau \bar{n}_o \Delta a$$

where $\bar{n}_o$ = average number of grains per unit area. For a normalized grain density $\bar{n}_o = 1$, the above relation becomes

$$\Delta\sigma_o = (\tau^2 \Delta a)^{\frac{1}{2}}/\tau \Delta a$$

Integration over the aperture area yields the normalized relative deviation:

$$\sigma_o = \frac{[\lim \Sigma \tau^2 \Delta a]^{\frac{1}{2}}}{\lim \Sigma \tau \Delta a} = \frac{[\int\int f^2(x, y) dx dy]^{\frac{1}{2}}}{\int\int f(x, y) dx dy} \qquad (24)$$

* The asterisk on the value $N_e{}^*$ is used to indicate that this value is obtained when a random grain structure is scanned. Other values will be introduced subsequently.

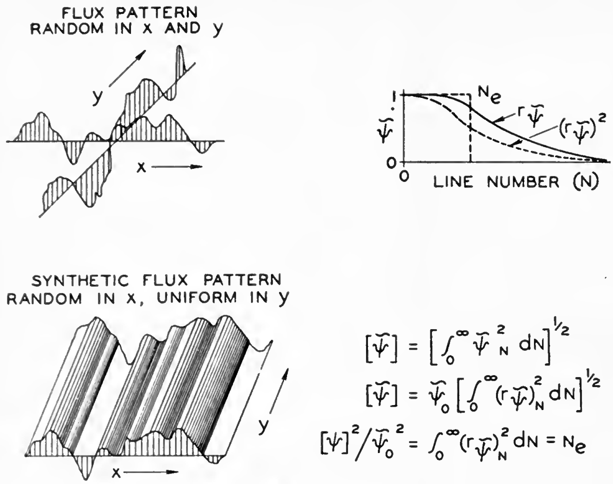
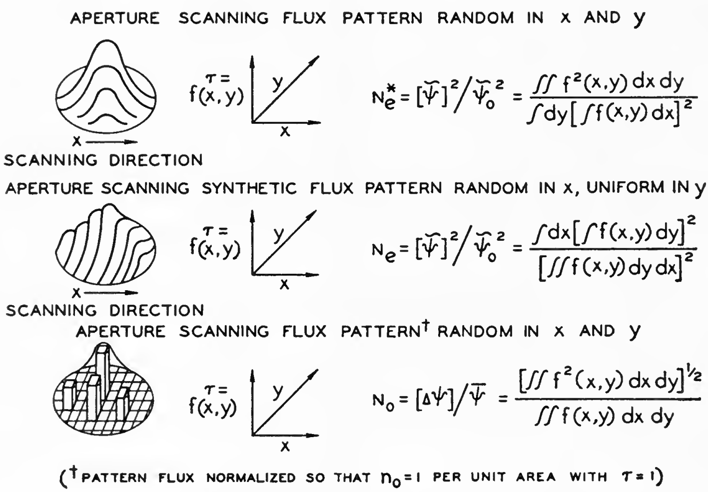


Fig. 48a. Normal and synthetic grain patterns.



(† PATTERN FLUX NORMALIZED SO THAT $n_0 = 1$ PER UNIT AREA WITH $\tau = 1$)

Fig. 48b. Subdivision of apertures for integration of flux values.

The normalized relative deviation σ_o has the dimension length^{-1}. The length may be regarded as the geometric mean of the sides of an equivalent rectangular sampling area a_e having constant transmittance $\tau = 1$. According to Eq. (19) the relative deviation $\sigma_o = 1/(a_e)^{\frac{1}{2}}$ can also be interpreted as the line number $\overline{N}_o$ of an equivalent square sampling aperture and Eq. (24) may, hence, be stated in the form:

$$\overline{N}_o = \frac{\left[\int\int f^2(x,y)dxdy\right]^{\frac{1}{2}}}{\int\int f(x,y)dxdy} \qquad (25)$$

The measure $\overline{N}_o$ is independent of the aperture position for both symmetric and asymmetric apertures and can, hence, be used as a standard for com-

parison. *The equivalent passband N_e^* of an aperture scanning a grain structure* random in x and y directions can be computed by subdividing the aperture into incremental sections parallel to the direction of scanning (see Fig. 48b). The mean squared flux obtained is the same as that obtained when the aperture is sampling. The flux $\bar{\psi}_{o(y)}$ at $N = 0$ contributed by each section to $\bar{\psi}_o$ is represented by the areas $\int \tau dx$ of the sections, and because the flux is random (out of phase) in y, the total flux ψ_o^2 is obtained by the sum of the squares $\bar{\psi}_o^2 = \Sigma[\int \tau dx]^2$. The measure N_e^* obtained when a random grain pattern is scanned is, therefore,

$$N_e^* = [\bar{\psi}]^2/\bar{\psi}_0^2 = \frac{\int\int f^2(x,y)dxdy}{\int dy[\int f(x,y)dx]^2} \quad (26)$$

The asterisk is used to distinguish N_e^* from the value N_e which will henceforth be used to indicate a sine-wave synthesis.

Evaluation of the equivalent passband N_e from a response characteristic obtained by the method of scanning sine-wave test patterns represents the case in which a synthetic structure random in the x direction but uniform (in phase) in the y direction is scanned. The aperture is subdivided into sections parallel to y. The mean-squared flux $[\bar{\psi}]^2$ is the sum of the squares of the section flux values $\Sigma[\int \tau dy]^2$, and the flux $\bar{\psi}_0^2$ is the squared sum of the section flux values, furnishing the ratio

$$N_e = [\bar{\psi}]^2/\bar{\psi}_0^2 = \frac{\int dx[\int f(x,y)dy]^2}{[\int\int f(x,y)dydx]^2} \quad (27)$$

All measures $\overline{N}_0$, N_e^* and N_e represent dimensionally a length^{-1}, but the formulations appear to have little resemblance to one another. Because the measures N_e^* and N_e depend on the direction of scanning, asymmetric apertures require evaluation of two N_e-values as stated by Eq. (23). For apertures having circular symmetry, however, the sampling equivalent $\overline{N}_o$ is seen to equal the geometric mean $(N_e^*\ N_e)^{\frac{1}{2}}$. To evaluate the relative accuracy of the three measures it is of interest to determine how closely the values computed with Eqs. (25), (26) and (27) compare in a number of representative cases. To provide N_e in relative units N_e/N_δ, the above equations must be multiplied by the ratio of the characteristic lengths δ/u when the length u chosen for computing the measure N_e differs from the length expressing a characteristic diameter of the aperture. In relative units Eqs. (25), (26) and (27) can be written:

$$\overline{N}_o/N_\delta = \frac{\delta}{u}\frac{[\int\int f^2(x,y)dxdy]^{\frac{1}{2}}}{\int\int f(x,y)dxdy} \quad (25a)$$

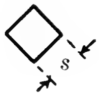
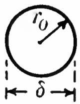
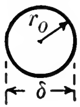
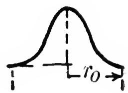
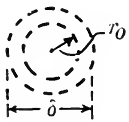
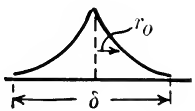
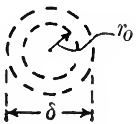
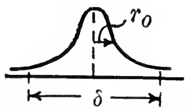
$$N_e^*/N_\delta = \frac{\delta}{u_x}\frac{\int\int f^2(x,y)dxdy}{\int dy[\int f(x,y)dx]^2} \quad (26a)$$

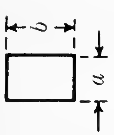
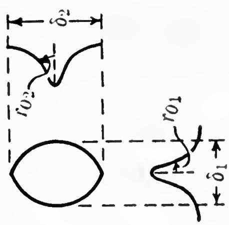
$$N_e/N_\delta = \frac{\delta}{u_x}\frac{\int dx[\int f(x,y)dy]^2}{[\int\int f(x,y)dydx]^2} \quad (27a)$$

It must be kept in mind that the length u in Eq. (25a) is the square root of an area and, therefore, independent of the aperture orientation. The length u_x in Eqs. (26a) and (27a), however, is always the characteristic aperture length in the direction x of scanning.

The measure N_e for a round aperture with $\tau = \epsilon^{-(r/r_o)^2}$, for example, may be computed in terms of a radius length $r_o = u_x$; the corresponding relative line number unit N_δ in Fig. 44 represents a length^{-1} measured by the diameter $\delta = 4r_o$. The ratio δ/u_x in this case is, therefore, four. The relative values in Table IV show that the sine-wave equivalent N_e is as good an equivalent as the value N_e^* obtained by the scanning of a random grain structure. Both values are somewhat in error for a round aperture with $\tau = 1$ and for a square scanned diagonally. Practical apertures such as lenses, grain structures or electron beams have nonuniform transmittances similar to the aperture types 4 to 6 in Table IV, for which the error is negligible or zero. The definition of N_e^* as the integral of squared response factors

Table IV. Relative Passband-Equivalents of Apertures.

No.	Aperture type		$\tau = f(x, y)$		δ	$\overline{N}_o/N\delta$	$N_e^*/N\delta$	$N_e/N\delta$
1	Square			$\tau = 1$	s	1	1	1
2	Square			$\tau = 1$	s	1	$1/(2/3)\sqrt{2} = 1.06$	$(2/3)\sqrt{2} = 0.943$
3	Round			$\tau = 1$	$2r_o$	$2/\sqrt{\pi} = 1.13$	$3\pi/8 = 1.178$	$32/3\pi^2 = 1.08$
4	Round			$\tau = \cos^2 r$	$2r_o$	1.575	1.56	1.59
5	Round			$\tau = \epsilon^{-r/r_o}$	$6r_o$	$6/\epsilon\sqrt{\pi} = 1.245$		1.245
6	Round			$\tau = \epsilon^{-(r/r_o)^2}$	$4r_o$	$4/\sqrt{2\pi} = 1.596$	1.596	1.596

7		$\tau = 1$	$\overline{N}_o = 1/\sqrt{ab}$	$N_{e(a)} = 1/a$ $N_{e(b)} = 1/b$	$\overline{N}_e = 1/\sqrt{ab}$ for $a = \delta$; $\overline{N}_e/N\delta = \sqrt{a/b}$
8		$\tau = \epsilon^{-(r/r_o)^2}$ $\delta_1 = 4r_{o1}$ $\delta_2 = 4r_{o2}$	$\overline{N}_o = 1/\sqrt{r_{o1}r_{o2}2\pi}$	$N_{e(1)} = 1/r_{o1}\sqrt{2\pi}$ $N_{e(2)} = 1/r_{o2}\sqrt{2\pi}$	$\overline{N}_e = 1/\sqrt{r_{o1}r_{o2}2\pi}$ $\overline{N}_e/N\delta_1 = 4\sqrt{\delta_1/\delta_2 2\pi}$

given by Eq. (22) applies also to the measure N_e, which is obtained from a sine-wave synthesis; i.e.,

$$N_e = {}_0\int^{\infty}(r\psi)^2{}_N dN \qquad (28)$$

The results obtained by a numerical integration of the squared aperture response according to Eq. (28) are illustrated by the curves $N_{e(o\rightarrow N)}$ in Figs. 41 to 46 which show the growth of the partial integral when the limit is increased from $N = 0$ towards $N = \infty$. The accurate agreement of the values obtained by this method is a check on the accuracy of the sine-wave response characteristics as well as the formulation of Eq. (27). The ϵ^{-r/r_o} aperture is of interest as a mathematical equivalent to grain structures with finite thickness. The line-number scale of this aperture is referred to a diameter $\delta = 6r_o$ which for identical values N_e places the rated resolution N_{cr} of film at the value $N_{cr}/N_\delta = 1.245/0.241 = 5.17$ of the theoretical characteristic. A comparison of Figs. 46a and 46b shows an almost perfect agreement of the sine-wave response characteristics. The resolving or sampling aperture of grain structures is, therefore, well represented† by a round aperture with a transmittance $\tau = \epsilon^{-r/r_o}$.

The value $\overline{N}_e$ of an asymmetric aperture of length a and width b can be determined accurately when the deformation of the dimensions a or b from circular symmetry does not alter the relative aperture transmittance in the b or a dimension, respectively. In this case the sine-wave measure $N_{e(a)}$ or $N_{e(b)}$ obtained with Eq. (27a) is determined by the dimension of the aperture (a or b) which is oriented parallel to the direction x of scanning, the measure being independent of the aperture scale

† A finite grain size removes the pointed tip of the aperture transmittance. The effect, however, is negligible because the flux contributed by a transmittance exceeding the value $\tau = 0.65$, ($r = 0.6\ r_o$) is only 2.5% of the total flux.

Table V. Evaluation of N_e for 40-mm Ciné Ektar Lens at f/1.6 (5°).

N/mm	r_ψ	$\bar{a}$	$\bar{a}^2\Delta N$	$\Sigma(\bar{a})^2\Delta N$
10	0.98	0.99	9.8	
20	0.94	0.96	9.2	
30	0.90	0.92	8.5	
40	0.85	0.88	7.75	
50	0.79	0.82	6.7	41.95
60	0.74	0.765	5.85	
70	0.67	0.70	4.9	
80	0.62	0.65	4.22	
90	0.57	0.59	3.5	
100	0.53	0.55	3.0	63.42
120	0.46	0.49	4.8	
140	0.42	0.44	3.88	
160	0.39	0.40	3.2	
180	0.36	0.37	2.76	
200	0.33	0.345	2.38	80.44
250	0.27	0.30	4.5	
300	0.20	0.23	2.65	
350	0.14	0.17	1.45	
400	0.08	0.11	0.61	
450	0.03	0.05	0.13	89.78

N_e = 90 Lines/mm

Table VI. Evaluation of N_e for Grain Structures.

N/N_{cr}	r_ψ	$\bar{a}$	$\bar{a}^2\Delta N$	$\Sigma(\bar{a})^2\Delta N$
0.05	0.97	0.985	0.049	
0.10	0.91	0.95	0.045	0.094
0.15	0.835	0.88	0.0385	
0.20	0.740	0.79	0.031	0.1635
0.25	0.67	0.685	0.0235	
0.30	0.53	0.585	0.0171	0.2041
0.35	0.44	0.50	0.0125	
0.40	0.37	0.41	0.0084	0.225
0.45	0.30	0.335	0.0055	
0.50	0.245	0.275	0.0038	0.2343
0.55	0.20	0.22	0.0024	
0.60	0.16	0.18	0.0016	0.2383
0.65	0.125	0.14	0.0010	
0.70	0.10	0.11	0.0006	0.240
0.75	0.075	0.085	0.00035	
0.80	0.058	0.065	0.0002	0.2405
0.85	0.04	0.045	0.0001	
0.90	0.03	0.04	0.0001	0.2407
0.95	0.02	0.03		
1.0	0.018	0.02		0.241

N_e = 0.241 N_{cr}

factor in the y direction. The aperture is thus simply considered first as an aperture with circular symmetry and a diameter $\delta = a$, furnishing the value $N_{e(a)}$, and second as an aperture with the diameter $\delta = b$, furnishing the value $N_{e(b)}$. The geometric mean of these values (Eq. (23)) furnishes the symmetric equivalent $\overline{N}_e$. The corresponding procedure when the sine-wave response of an astigmatic lens is measured, for example, requires orientation of the sine-wave pattern and scanning direction parallel or perpendicular to the direction of astigmatism. The values $N_{e(a)}$ and $N_{e(b)}$ are then determined by numerical integration from the two corresponding sine-wave response characteristics (Eq. (28)). The evaluation of $\overline{N}_e$ is illustrated by two examples in Table IV.

The numerical evaluation of the measure N_e from a sine-wave response characteristic by means of Eq. (28) is illustrated by Table V for a 40-mm f/1.6 Ciné Ektar lens measured at f/1.6 and 5° off axis. The value $\bar{a}$ is the mean response factor within the increment ΔN. The equivalent passband N_e is obtained directly in television lines per millimeter; N_e = 90 lines/mm. Table VI illustrates the evaluation of N_e for grain structures from Fig. 46b in relative units. With reference to the rated resolving power N_{cr} of film, N_e = 0.241 N_{cr}. Hence, for fine-grain positive film (Type 5302) with N_{cr} = 180 *television* lines per millimeter, N_e = 43.4 lines/mm.

4. Equivalent Aperture Diameters

The line number for known round apertures is expressed in relative units N/N_δ which refer to the aperture diameter

$$\delta = l/N_\delta$$

where l is the unit of length (l = 1 millimeter, or $l = V$ = vertical picture dimension). Relative to the equivalent passband $N_e = kN_\delta$, the diameter of these apertures is expressed by the relation $\delta = lk/N_e$ given in Table VII.

An equivalent aperture or point image of specified characteristics can thus be obtained for a system element by the

Table VII. Diameter δ and Equivalent Passband N_e of Various Aperture Types.

Aperture type	Relative transmittance	Diameter (δ)	Relation of δ to N_e
Square	$\tau = 1$	s	$s = l/N_e$
Round	$\tau = 1$	$2r_o$	$\delta_o = 1.08\, l/N_e$
Round	$\tau = \cos^2 r$	$2r_o$	$\delta_{\cos} = 1.59\ l/N_e$
Round	$\tau = \epsilon^{-r/r_o}$	$6r_o$	$\delta\epsilon = 1.245\, l/N_e$
Round	$\tau = \epsilon^{-(r/r_o)^2}$	$4r_o$	$\delta_{ex} = 1.6\, l/N_e$

insertion of its N_e-value into the relations given in Table VII.

The equivalent passband N_e (television lines) and the equivalent aperture sizes of a number of system elements used in photographic processes are summarized in Table VIII.

5. Equivalent Passband and Aperture Diameter of Processes Containing a Number of Elements in Cascade

The sine-wave response characteristic of a number of system elements in cascade, including the eye if desired, can be computed accurately by forming the products of the response factors $r_{\psi 1}\, r_{\psi 2} \ldots r_{\psi n}$ of actual response characteristics at corresponding line numbers. The equivalent passband $N_{e(p)}$ of the process is thus given accurately by the integral

$$N_{e(p)} = {}_0\!\int^{\infty} (r_{\psi 1}, r_{\psi 2}, \ldots r_{\psi n})^2 dN \quad (29)$$

Because of the nature of the response characteristics of lenses, films and television tubes it has been found that the equivalent sampling area of a combination of such "apertures" can be evaluated with usually less than 5% error by simply adding the equivalent aperture areas of the components or, as expressed in terms of equivalent aperture diameters:

$$\delta_{(p)} \simeq (\delta_1^2 + \delta_2^2 + \ldots + \delta_n^2)^{\frac{1}{2}} \quad (30a)$$

$$1/N_{e(p)} \simeq (1/N_{e_1}^2 + 1/N_{e_2}^2 + \ldots + 1/N_{e_n}^2)^{\frac{1}{2}} \quad (30b)$$

It thus becomes a simple matter to compute the equivalent passband $N_{e(p)}$ and the aperture diameter of photographic systems by the use of Eq. (30) in conjunction with Table VIII. Equation (30) is exact for exponential apertures $\tau = \epsilon^{-(r/r_o)^2}$ because the response characteristic (Fig. 44) has the form $r\psi_{(N)} = \epsilon^{-KN^2}$. The response characteristic of a system of two-dimensional apertures tends to approach this form (Fig. 44), which may therefore be used as an *equivalent response characteristic* with a line number scale $N\delta = N_e/1.6$.

The simplified method will lead to larger errors and should not be used when electrical components of a television system such as amplifiers or filters with sharp cutoff or a rising frequency characteristic are included. Although equivalent passbands (N_e) for such components have a significance, they cannot be treated as normal optical apertures. It is well known, for example, that any number of amplifier stages of limited range can be combined and corrected to have an overall "flat" response characteristic. It must also be kept in mind that the measure N_e of an optical aperture is used as a substitute for $\overline{N_o}$ and normally refers to the property of an area. N_e differs, therefore, from the "noise equivalent bandwidth" $\Delta f_{(\mathrm{eq})}$ of an electrical frequency-response characteristic which dimensionally refers to a length. Combinations of electrical components with two-dimensional apertures will be discussed in Part III.

Table VIII. Equivalent Passband (N_e) and Diameter (δ_o) of Equivalent Round Sampling Aperture of Imaging Components.

		N_e		δ_o (microns)	
Theoretical lens	$f/4$	287	L/mm	3.76	(See Fig. 45)
	$f/6.3$	182		5.95	
	$f/8$	143		7.52	
	$f/16$	72		15	
40-mm Ciné Ektar at	$f/1.6$ (5°)	90	L/mm	12	(Table V)
at	$f/2.8$ (5°)	180		6	
50-mm Baltar at	$f/2.8$ (5°)	64		17	(Table IX)
4-in. Super Cinephor	$f/2$	27.3		39.5	(Table IX)
Film	N_{cr}*	0.241	N_{cr}	(See Fig. 46b)	* N_{cr} = "rated" resolution at $r\bar{\psi} \simeq 2\%$.
Plus X	110 L/mm	26.5	L/mm	40.8	
Fine-grain negative (5203)	220	53		20.4	
Fine-grain positive (5302)	180	43.4		25	
16mm reversal	150	36		30	
Square spot	$\tau = 1$	0.50	N_c**	(See Fig. 41)	** N_c = Limiting resolution at $r\bar{\psi} = 2\%$.
Round spot	$\tau = 1$	0.45	N_c	(See Fig. 42)	
Round spot	$\tau = \cos^2 r$	0.38	N_c	(See Fig. 43)	
Exponential spot	$\tau = \epsilon^{-r/r_o}$	0.244	N_{cr}*		
Exponential spot	$\tau = \epsilon^{-(r/r_o)^2}$	0.222	N_c	(See Fig. 44)	
Theoretical lens		0.305	N_c	(See Fig. 45)	

D. GRANULARITY AND RANDOM FLUCTUATIONS IN MOTION PICTURE PROCESSES

An objective analysis of the luminance fluctuations caused by the grain structure in motion pictures requires evaluation of three factors: (1) the law of sample distribution at the source of deviations, (2) the effect of nonlinear transfer characteristics of system components on the signal-to-deviation ratio, and (3) the effect of the system apertures on the total luminance fluctuation and the sine-wave spectrum in the final image.

Subjective effects such as the appearance and threshold visibility of fluctuations (graininess) depend on the fluctuation level, gamma and aperture effect of the process of vision and can be evaluated by including the characteristics of the eye in the imaging process.

1. Deviation Characteristics of Photographic Film

The sensitometric curves of film showing the grain density D as a function of exposure E are a graph of the relative sample number as a function of exposure because

$$D \propto n/a$$

If a random distribution is assumed and $\bar{n}'$ is made equal to the average grain number (in a) at $D = 1$, the rms deviation becomes

$$[\Delta D] = (\bar{n}'D)^{\frac{1}{2}} \tag{31}$$

Density and light transmittance of the film are connected by the relation

$$D = -\log \tau$$

Differentiation of this function

$$dD/d\tau = -(\log \epsilon)/\tau = -0.4343/\tau \tag{32}$$

establishes the fact that small deviations ΔD in density or grain number cause a reciprocal deviation $\Delta\tau$ in transmittance. The relative deviation in transmittance is therefore

$$\sigma_\tau = [\Delta\tau]/\tau = 2.31[\Delta D] \tag{33}$$

and with (31)

$$\sigma_\tau = 2.31(D\bar{n}')^{\frac{1}{2}} \tag{34}$$

The effective grain number $\bar{n}'$ in actual films may, hence, be determined from measurements of σ_τ and D with

$$\left.\begin{aligned} \sigma_D &= 0.4343\,\sigma_\tau/D \\ \text{and} \qquad \bar{n}' &= (2.31/\sigma_\tau)^2 D \end{aligned}\right\} \tag{35}$$

This simple relation is accurate for small deviations $\sigma_\tau < 0.1$.

Random deviations $[\Delta]_f$ caused by sources other than exposure to light, such as fog, dust and other irregularities, may superimpose a constant deviation level which remains at zero exposure. The total deviation is then increased to the value

$$[\Delta]' = ([\Delta]^2 + [\Delta]_f{}^2)^{\frac{1}{2}}$$

and

$$\sigma_\tau' = 2.31([\Delta D]^2 + [\Delta D]_f{}^2)^{\frac{1}{2}} \tag{36}$$

When both density and $[R]_\tau$ are plotted in logarithmic units (see Fig. 49) the curves showing $[R]_\tau$ as a function of density become straight lines having a slope of minus one-half for random distributions. In this case the effect of an unknown constant deviation causes at low densities a departure of measured values from a straight line. When the addition of a constant value D_f to the measured values brings the points into line, the deviations have a random distribution. The results of deviation measurements (see Appendix) made with round sampling apertures on a number of film types are shown in Figs. 49, 50, 51 and 52. The diameter δ of the sampling aperture is indicated.

Various causes introducing extraneous deviations were noted. Variations or irregularities in the transmission of the film base, thickness of the emulsion, photosensitivity, uniformity of development or physical defects introduce deviations similar to the various defects which can occur and modify the frequency distribution and consistency of

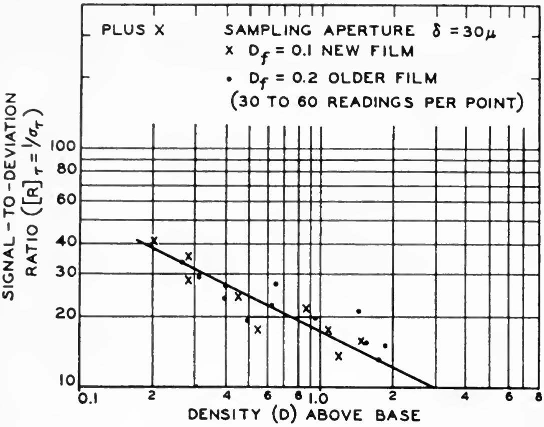


Fig. 49. Deviation characteristic of Plus X Negative Film.

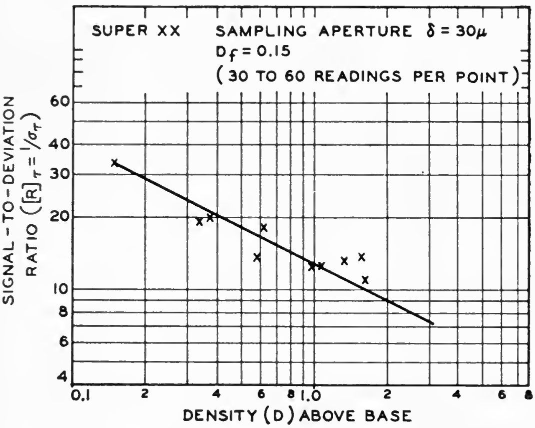


Fig. 50. Deviation characteristic of Super XX Negative Film.

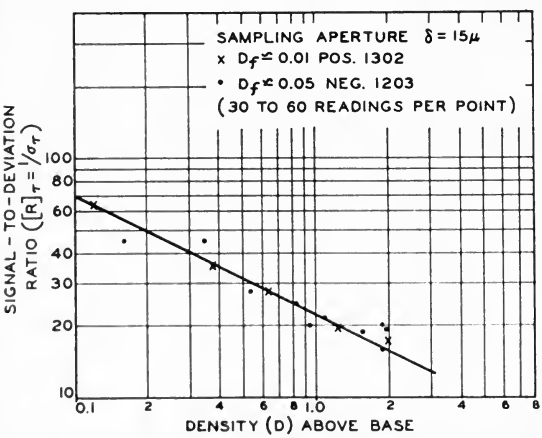


Fig. 51. Deviation characteristic of fine-grain film.

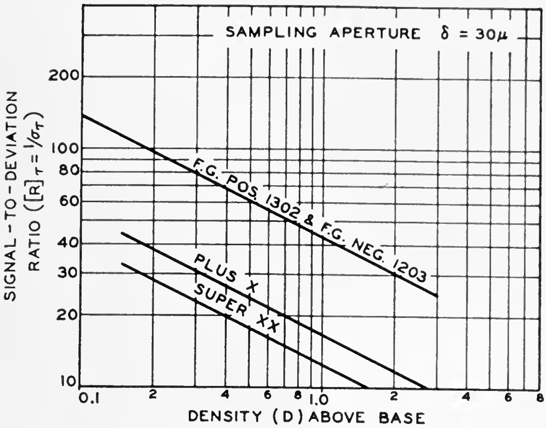


Fig. 52. Deviation characteristics of several film types.

electrical fluctuations in television systems. In comparison with the immense number of samples involved in a dynamic measurement of electrical fluctuations it can be expected that static sample measurements on a small film area will show a greater spread of values.

The measured characteristics (Figs. 49, 50 and 51) substantiate the variation of $[R]_\tau$ with the one-half power of the grain density predicted by Eq. (34) for a random distribution. Additional proofs can be obtained directly from any one set of sample readings taken to determine a point on the $[R]_\tau$ characteristics. When the readings are plotted on probability paper (arranged in order according to value), a gaussian distribution of values is indicated by a grouping around a straight line. Figure 53 shows the distribution of readings determining three points on the $[R]_\tau$ characteristic of Plus X film and one point on the characteristic of fine-grain positive film.

These plots may be compared with Fig. 54 which shows two sets of sample readings taken on photographs of electrically produced "grain" structures in a single television frame. The photographs were made on 4 × 5 in. film, a positive of which was sampled with a round aperture. The electrical fluctuations so recorded are random fluctuations occurring in the current of a multiplier phototube exposed to a "d-c" light source and passed through electrical amplifiers having a constant or a rising (peaked) frequency response characteristic. The agreement with the theory is sufficiently good to justify the assumption that the *deviations in motion picture film are substantially gaussian* and certainly random as defined in Sec. C1.

A comparison of deviation ratios in film types is made on the basis of sampling apertures having equal areas or equivalent optical passbands. For a random distribution of samples, the deviation ratio $[R]_\tau$ is proportional to the diameter δ of a round sampling aperture. The curve for fine-grain film in Fig. 52 is, therefore, obtained from Fig. 51 by multiplying the $[R]_\tau$-scale by the ratio of the aperture diameters. The validity of this process can be demonstrated visually by photomicrographs of equal densities on Plus X and 1302 positive film. For equal magnification the grain structures are shown by the prints 0 and 1a in Fig. 55. Magnifications in the ratio of their $[R]$-values results in equal deviations per unit area in the prints 1 and 1a. Out-of-focus projections are a convenient means for reducing the optical passband and thus visually checking the relative "frequency" distribution of the devia-

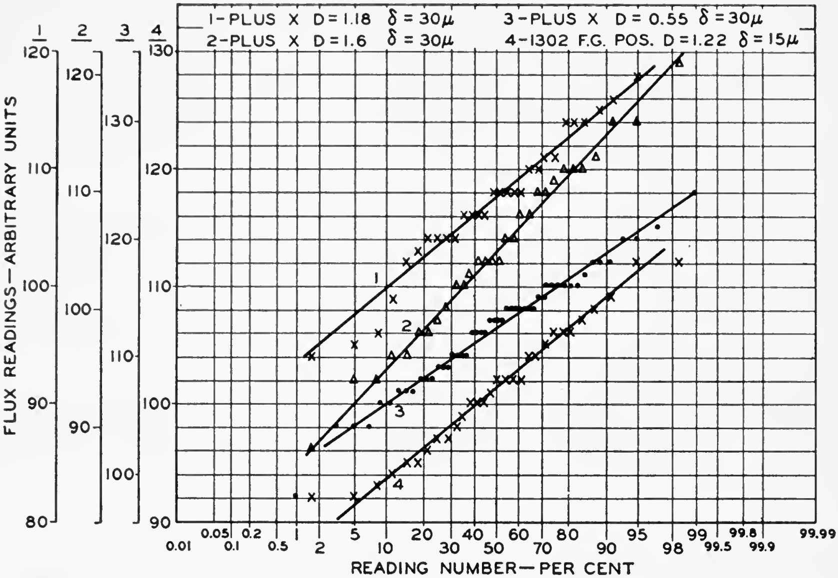


Fig. 53. Sample readings on Plus X and fine-grain films plotted on probability paper.

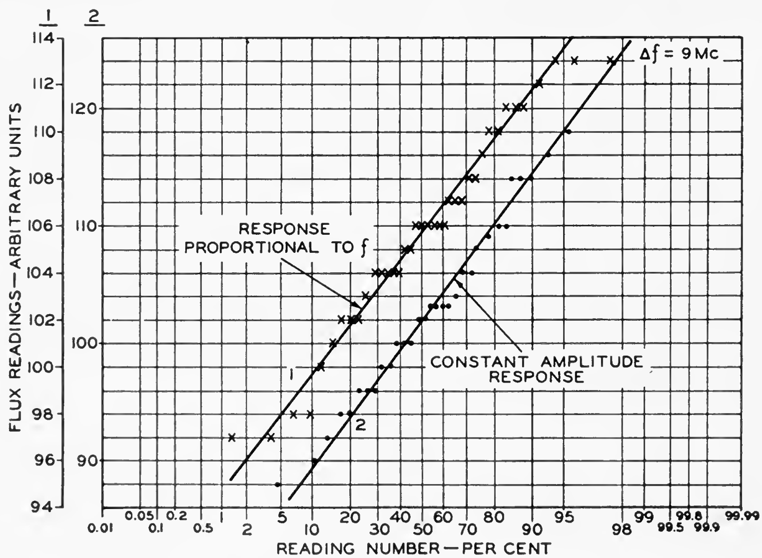


Fig. 54. Sample readings of television "noise" photographed on 4×5 in. film plotted on probability paper.

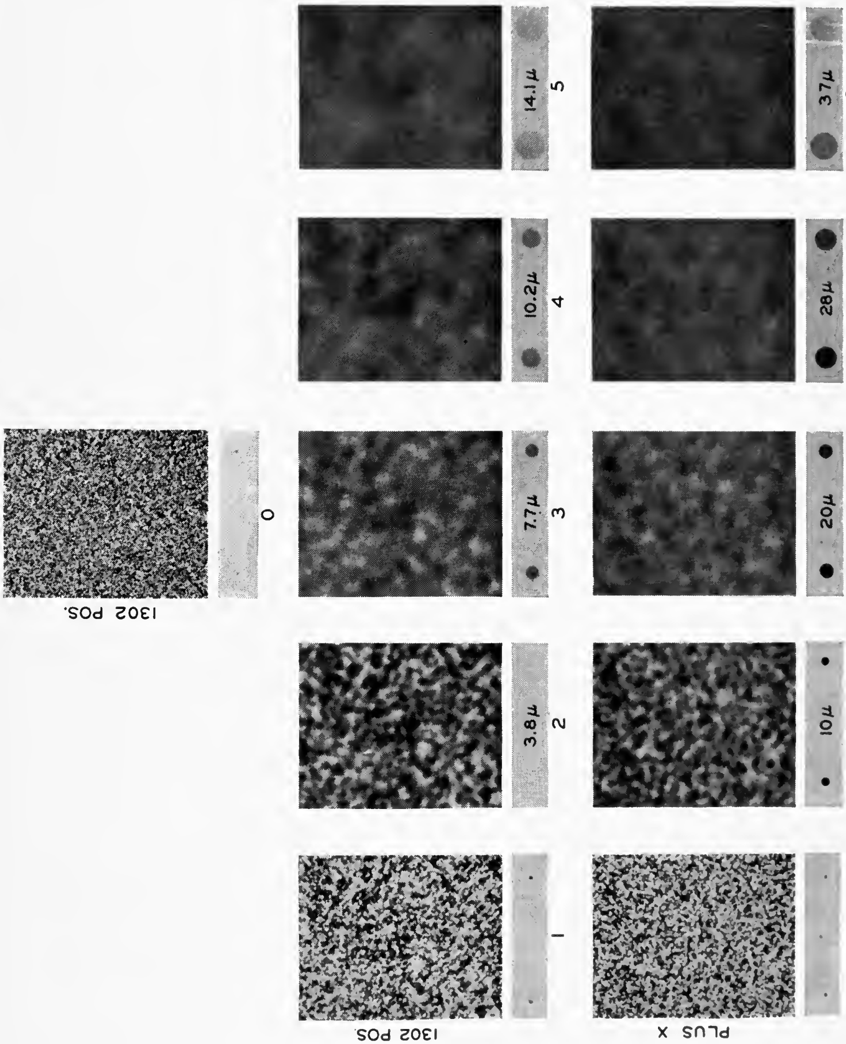


Fig. 55. Comparison of grain structures in photographic film after integration by aperture processes.

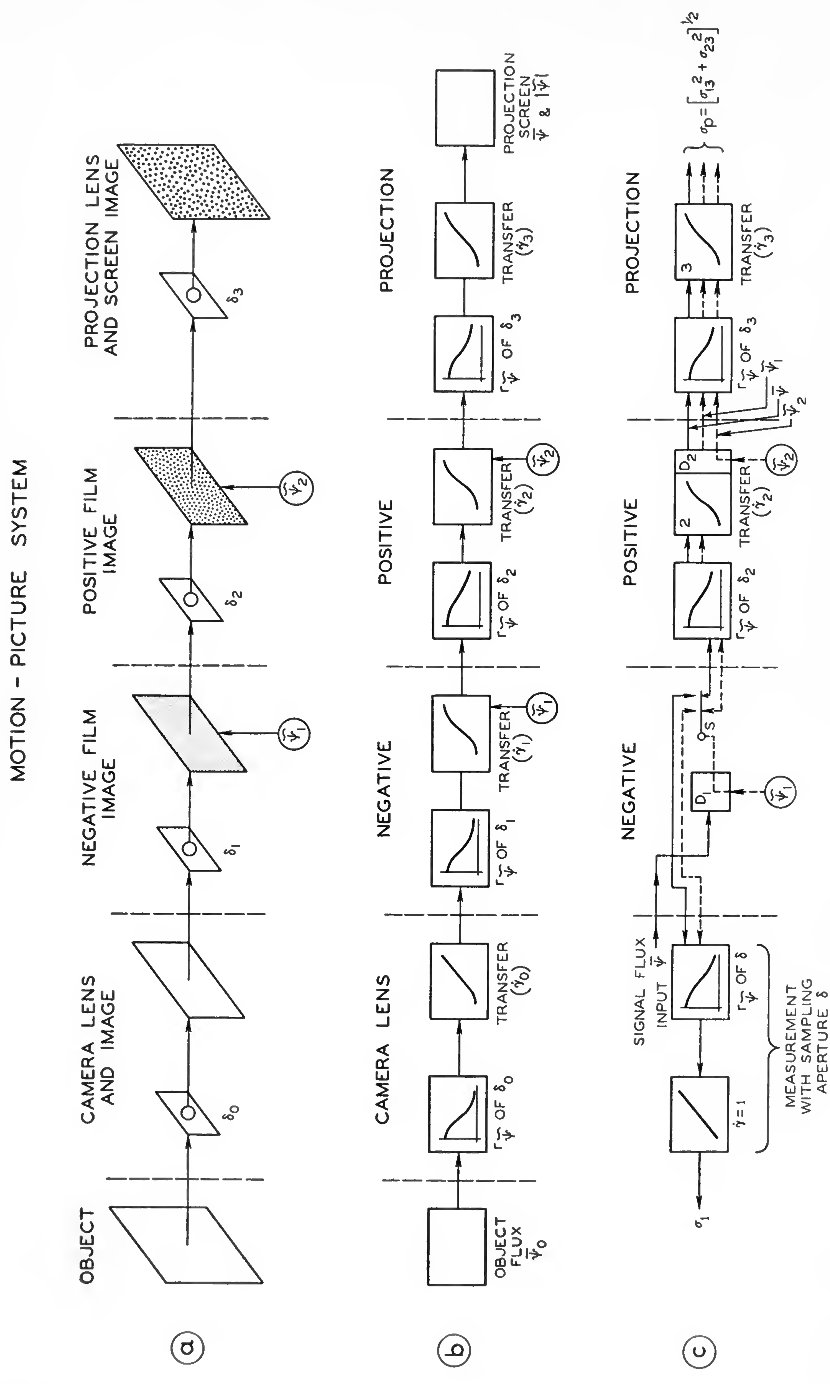


Fig. 56. Block diagrams of motion picture system.

tions, because the optical passband decreases in proportion to the diameter of the disc of confusion (sampling aperture) in the out-of-focus projection. The integrated grain structures 2, 2a, 3, 3a, etc., of the two film types have a substantially identical appearance for passbands in the ratio of their $[R]$-values, confirming a substantially identical distribution. The size of the integrating aperture of the projection is shown by pinhole images under the grain images. The aperture sizes are indicated in microns (μ).

2. Sampling Apertures and Transfer of Deviations in Motion Picture Systems

The four dominant sampling apertures and intermediate images of a motion picture system are shown in Fig. 56a. The corresponding aperture response characteristics $r_{\bar{\psi}} = f(N)$ of the system elements, their transfer characteristics $\psi_{\text{out}} = f(\psi_{\text{in}})$ and the points where random deviations ($\bar{\psi}$) are introduced into the system are indicated in Fig. 56b. It is assumed that no aperture effects are introduced by camera, printing and projector mechanisms.

A number of minor apertures have been omitted in the diagram because they are of much smaller magnitude than the main sampling apertures of the system. The *developed* grain structures of the negative and positive films, for example, introduce a small aperture effect in printing and projection processes in addition to their main aperture effect which occurs during exposure in the undeveloped grain structure. The diffusion of light and, consequently, the aperture effect of the black silver grain structure of the developed films, however, is of much smaller magnitude than in the undeveloped transparent state of the structure and can be neglected.

For an analysis of deviations the block diagram contains, therefore, only the elements shown in Fig. 56c indicating the dependence of the relative deviations σ_1 and σ_2 on the densities D_1 and D_2 of the respective film processes. The method of measuring the relative deviation (σ_1) in the negative film with a known sampling aperture (δ) is indicated by an alternate path of $\bar{\psi}_1$ over the switch S.

The value of the relative deviation has been determined by measurement for several motion picture film types with the use of a round sampling aperture of specified diameter δ. In the actual process (Fig. 56c), the deviation flux $\bar{\psi}_1$ from the negative is "filtered" by the response characteristics of the apertures δ_2 and δ_3 and passed through the transfer characteristics 2 and 3 to the projection screen. The sampling aperture δ used in the measurement of σ_1 is, hence, replaced by the cascaded value $\delta_{23} = (\delta_2{}^2 + \delta_3{}^2)^{\frac{1}{2}}$. According to Eq. (17) the deviation is changed in inverse proportion with the aperture diameter; it is further changed by the transfer ratios g/G,† i.e., the point gammas $\dot{\gamma}_2$ and $\dot{\gamma}_3$ of the two transfer characteristics. The relative deviation σ_1 from the negative is, therefore, changed after transfer to the projection screen to the value

$$\sigma_{13} = 1/[R]_{13} = \sigma_1(\delta/\delta_{23})\dot{\gamma}_2\dot{\gamma}_3 \quad (37a)$$

Similarly deviations originating in the positive film are changed from the measured value σ_2 to the value

$$\sigma_{23} = 1/[R]_{23} = \sigma_2(\delta/\delta_3)\dot{\gamma}_3 \quad (37b)$$

The total relative deviation σ_p at the projection screen is then obtained by a quadrature addition of the relative deviations σ_{13} and σ_{23} as illustrated by numerical examples in the following section.

3. The Signal-to-Deviation Ratio in Projected Positive Film

The signal-to-deviation ratio $[R]_p$ in a standard 35mm motion picture process is determined by the following

† See Part I, p. 145.

components: Plus X negative film, 1302 fine-grain positive film, and a 4-in. $f/2$ Super Cinephor projection lens. *The sampling aperture* δ_{23} *for deviations originating in the negative film* is the cascaded value of the equivalent aperture of the positive film ($\delta_2 = 25\mu$) and the equivalent aperture of the Super Cinephor projection lens ($\delta_3 = 39.5\mu$)

$$\delta_{23} = (25^2 + 39.5^2)^{\frac{1}{2}} = 46.7\ \mu$$

A second value

$$\delta'_{23} = (25^2 + 30^2)^{\frac{1}{2}} = 39\ \mu$$

representing a combination of the positive film and a physical 30-μ aperture will be used for test purposes. A tabulation of the response factors of motion picture components and combinations (products) is given in Table IX. (Note the close agreement of the equivalent apertures computed from the actual response characteristics with those obtained above.)

Representative transfer characteristics of the negative and positive films are shown in Figs. 14 and 15 of Part I. The total density values D_1 and D_2, the densities above base $D_1{}^*$ and $D_2{}^*$, and the point gamma of the positive film ($\dot{\gamma}_2$) are listed in Table X.

A projection lens having a linear transfer characteristic with a constant gamma of unity ($\dot{\gamma}_3 = 1$) requires a complete absence of lens flare and a totally dark and nonreflecting projection room. In all practical cases lens flare and ambient light superimpose a light flux "bias" $\bar{\psi}_0$ on the projection screen. The signal flux is, hence, increased by the ratio $(\bar{\psi} + \bar{\psi}_0)/\bar{\psi}$ which, as easily shown, reduces the constant value $\dot{\gamma}_3 = 1$ as a function of $\bar{\psi}$ to the values $\dot{\gamma}_3 = \bar{\psi}_3/(\bar{\psi}_3 + \bar{\psi}_0)$. Expressed in units of film transmittance

$$\dot{\gamma}_3 = \tau_2/(\tau_2 + \tau_b) \tag{38}$$

For a normal high light transmittance $\tau_{2\max} = 0.5$, a 1.5% light bias $\bar{\psi}_0 = 0.015\ \psi_{3\max}$ (compare Fig. 18, Part I) corresponds to the value $\tau_b = 0.015 \times \tau_{2\max} = 0.0075$ and $\dot{\gamma}_3 = \tau_2/(\tau_2 + 0.0075)$ which is listed in the lower portion of Table X for various values of D_0 and $\tau_2 + 0.0075$, the latter being proportional to the total screen luminance $B + B_0$. The effect of the light bias is computed separately by first letting $\dot{\gamma}_3$ equal unity. The ratio $[R]_1$ of the Plus X negative film measured with $\delta = 30\mu$ is taken from Fig. 52. The transferred values $[R]^*_{13}$, indicated by an asterisk, are computed with Eq. (37a) for the cascaded sampling apertures.

Table IX. Sine-Wave Response Factors of Motion Picture Components.

N/mm	Baltar at $f/2.8$	Neg. film Plus X	Fine-grain pos. 5203	Cinephor at $f/2$	Aperture 30 μ	3 + 4	3 + 5	1 to 4
10	0.99	0.93	0.97	0.94	0.97	0.91	0.94	0.84
20	0.95	0.78	0.90	0.80	0.91	0.72	0.82	0.54
30	0.90	0.60	0.815	0.60	0.80	0.49	0.652	0.26
40	0.82	0.43	0.70	0.45	0.66	0.315	0.462	0.111
50	0.74	0.30	0.59	0.33	0.51	0.195	0.30	0.044
60	0.66	0.205	0.48	0.25	0.35	0.12	0.168	0.016
70	0.58	0.14	0.39	0.18	0.22	0.07	0.084	0.006
80	0.50	0.09	0.31	0.13	0.09	0.04	0.028	
90	0.45	0.07	0.25	0.10	0	0.025		
100	0.40	0.03	0.20	0.08		0.016		
No.	1	2	3	4	5	3 + 4	3 + 5	1 to 4
N_e/mm	64	26.5	43.4	27.3	36	23.5	27.8	15.8
$\delta_o(\mu)$	17	40.8	25	39.5	30	46	39	68
			Computed with Eq. (30): δ_{p_o} =			46.7	39	64.5

Table X. Signal-to-Deviation Ratios for Plus X Negative Film Copied on 5302 Fine-Grain Positive Film and Sampled by an Aperture

Sampling aperture					δ	δ_{23}	δ_{23}	δ_3	δ_3	δ_{23} & δ_3	δ_{23} & δ_3
Microns					30	39	46.7	30	39.5	39 & 30	46.7 & 39.5
D_1	D_2	D_1*	D_2*	$\dot{\gamma}_2$	$[R]_1$	$[R]^*_{13}$	$[R]^*_{13}$	$[R]^*_{23}$	$[R]^*_{23}$	$[R]^*_p$	$[R]^*_p$
0.36	2.77	0.2	2.72	1.66	38	30	35.8	26	34.2	19.6	24.7
0.64	2.3	0.48	2.25	1.85	25	17.5	21	29	38.2	15	18.5
0.75	2.1	0.59	2.05	1.95	22	14.6	17.5	30.5	40.2	13.1	16
0.88	1.9	0.73	1.85	2.0	20	13.0	15.6	32	42	12.1	14.6
1.0	1.6	0.84	1.55	2.0	18.5	12.0	14.4	35	46.1	11.3	13.7
1.13	1.35	0.97	1.3	1.88	17.5	12.1	14.5	38	50	11.5	13.8
1.37	0.91	1.21	0.86	1.57	15.5	12.8	15.3	47	62	12.35	14.9
1.6	0.6	1.44	0.55	1.21	14.5	15.6	18.7	59	78	15.1	18.2
1.79	0.4	1.63	0.35	0.9	13.2	19.1	23	74	97.5	18.75	22.3
1.95	0.27	1.79	0.22	0.64	12.8	26.0	31.2	93	122	25	30.2
2.1	0.19	1.94	0.14	0.4	12.3	40	48.0	118	155	38	46.0

	$\tau_2 + 0.0075$	D_2	$\dot{\gamma}_3$	$[R]_p$	$\Upsilon_{13}/\Upsilon_{23}$	Υ_p/Υ_{23}	δ_{po}	$N_{e(p)}$
(Sampling aperture: δ_{23} & δ_3; microns, 46.7 & 39.5)	0.009	2.77	0.227	109	1.04	1.44	42.6	25.4
	0.0125	2.3	0.4	46.3	1.97	2.21	45.5	24
	0.016	2.1	0.515	31	2.5	2.69	45.5	24
	0.020	1.9	0.63	23.2	2.92	3.08	45	24
	0.033	1.6	0.77	17.8	3.48	3.62	45.9	23.6
	0.052	1.35	0.86	16	3.75	3.87	45	24
	0.13	0.91	0.94	15.9	4.4	4.5	46.3	23.6
	0.258	0.6	0.97	18.8	4.53	4.65	46.6	22.1
	0.405	0.4	0.98	22.8	4.6	4.71	46	22.6
	0.544	0.27	0.985	30.7	4.25	4.36	46.1	23.5
	0.652	0.19	0.99	46.5	3.52	3.66	46.5	23.2
			Eq. (38) $\tau_b = 0.0075$		Eq. (42)	Eq. (43)	Eq. (45)	

Note: The values $[R]^*$ are computed for zero lens flare and zero ambient light ($\tau_b = 0$, $\gamma_3 = 1$)

$\delta'_{23} = 39\mu$ and $\delta_{23} = 46.7\mu$ letting γ_3 equal unity. The signal-to-deviation ratios $[R]^*_{23}$ of the positive film alone are tabulated likewise for the density values D_2^* (from Fig. 52) and the sampling apertures $\delta'_3 = 30\mu$ and $\delta_3 = 39.5\mu$ (cinephor lens). The total signal-to-deviation ratio $[R]^*_p$ in the projection is then computed with

$$1/[R]^*_p = (1/[R]^{*2}_{13} + 1/[R]^{*2}_{23})^{\frac{1}{2}} \quad (39)$$

Division of the values $[R]^*_p$ by corresponding values $\dot{\gamma}_3$ furnishes the values $[R]_p$ containing the effect of the light bias $\bar{\psi}_0$.

A comparison of the values $[R]^*_{13}$ from the negative alone with the values $[R]^*_p$ of the process shows that the fine grain of the positive film contributes little to the total deviation. As illustrated by the block diagram Fig. 56c, the total deviation is a composite value of deviations from two unequal pass-bands and requires further discussion.

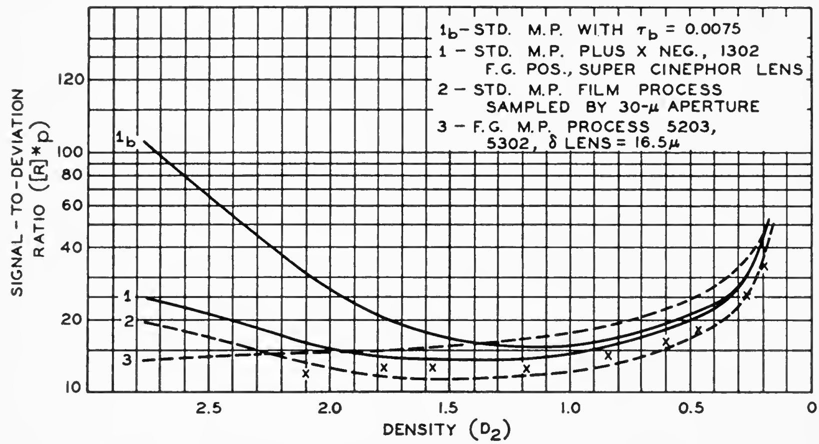


Fig. 57a. Deviation characteristic of projected motion picture without ambient light.

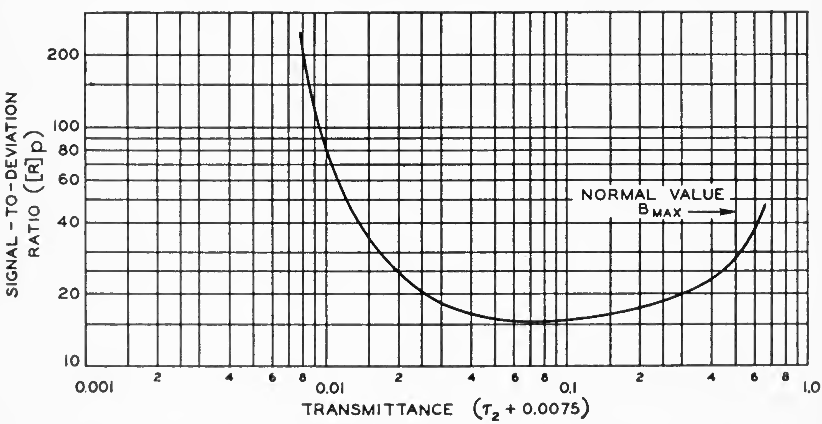


Fig. 57b. Deviation characteristic of projected motion picture with ambient light.

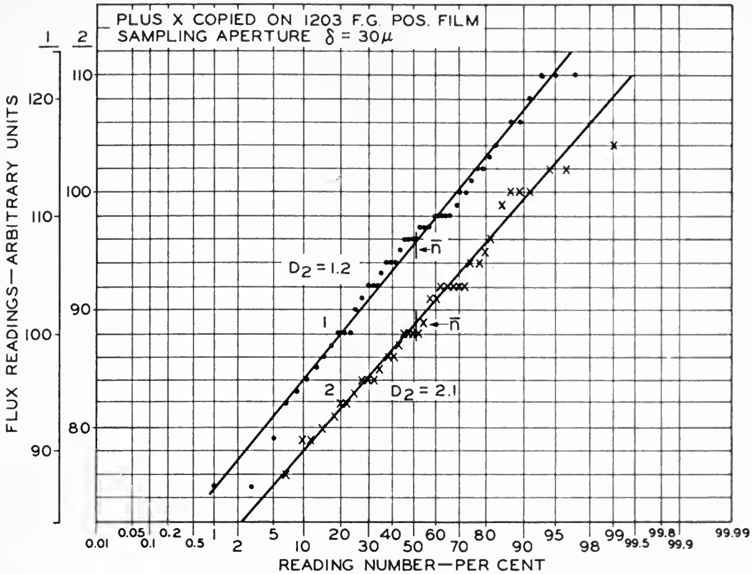


Fig. 58. Sample readings on motion picture positives plotted on probability paper.

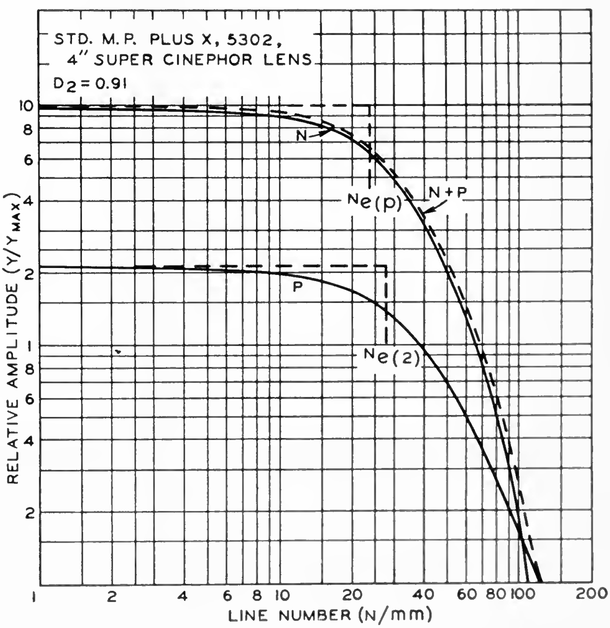


Fig. 59. Sine-wave spectrum of deviations in motion picture process.

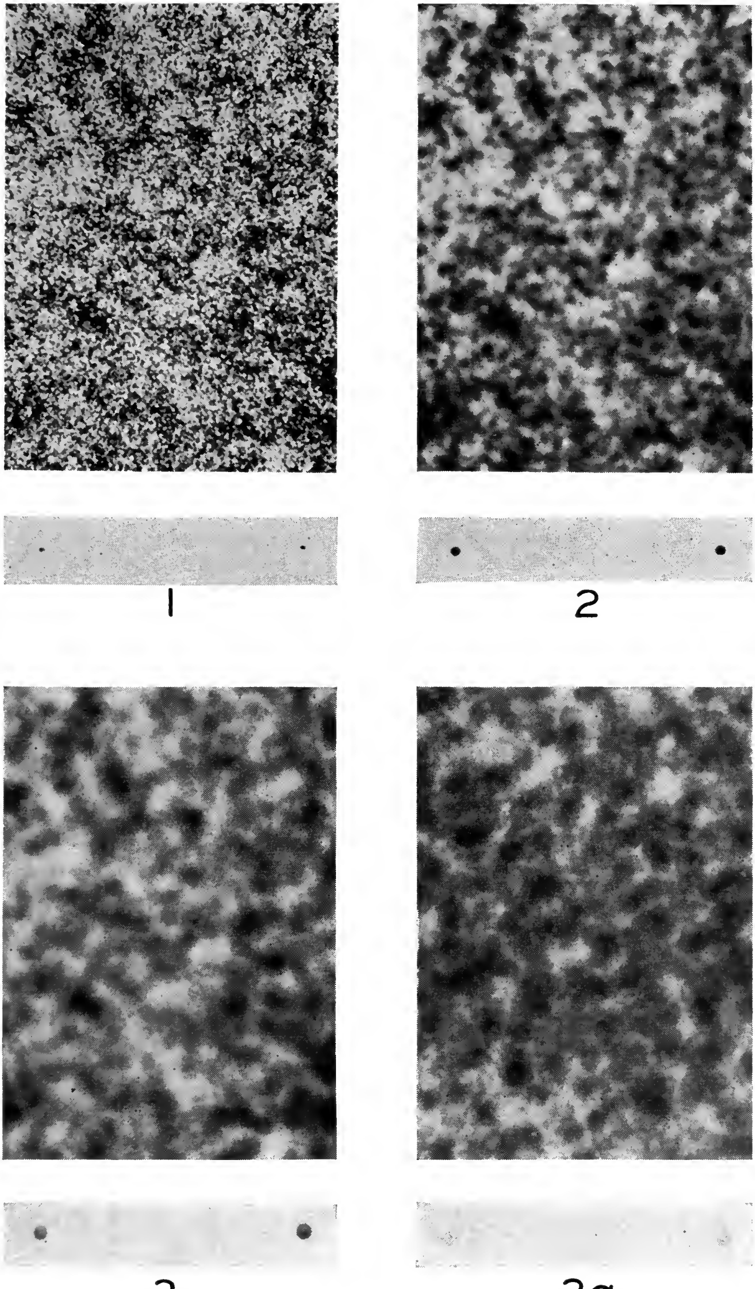


Fig. 60. Composite grain structures in motion picture positives.

A plot of the signal-to-deviation ratios $[R]^*_p$ and $[R]_p$ from Table X is shown in Figs. 57a and 57b, illustrating the considerable reduction of deviations and corresponding improvement of $[R]_p$ in the shadow tones by ambient light. The broken line, curve 2 in Fig. 57a, for a 30-μ aperture was computed for comparison with a direct measurement. The measured values (x) were obtained by sampling a contact print (on 5302 stock) of a IIB sensitometer exposure on Plus X film with a 30-μ aperture (spray process on negative, deep tank on positive by De Luxe Laboratories). The agreement with computed values is good, particularly when it is considered that optical effects and film slippage in printing cause additional integration and increase the sampling aperture and $[R]^*$-values. Figure 58 shows that the gaussian distribution is maintained in the composite structure sampled by a 30-μ aperture.

4. The Optical Passband of the Total Deviation in Projected Positive Film

The sine-wave components of different passbands are combined into a single passband by a geometric addition of like sine-wave components. To perform this addition the relative values of corresponding Fourier components must be known. The flux $\bar{\psi}_0$ representing the flux or amplitude Υ_o of the Fourier component approaching zero line number is obtained from Eqs. (27) and (20) $\bar{\psi}_0 = \bar{\psi}\sigma/N_e^{\frac{1}{2}}$. Substitution of $1/N_e = c^2\delta$ from Table VII yields

$$\Upsilon_o = c\bar{\psi}\delta^{\frac{3}{2}}\sigma = c\bar{\psi}\delta^{\frac{3}{2}}/[R] \qquad (40)$$

in which c is a numerical constant.

Because the relative deviation (σ) itself is proportional to $1/\delta$ and $\bar{\psi}$ is proportional to δ^2, Eq. (40) reveals the interesting fact that the amplitude of the zero-line number component (Υ_o) or ($\bar{\psi}_o$) increases with the 3/2 power of the diameter of the sampling aperture; a fact having no parallel in electrical filter circuits. The amplitudes of the zero line number components in the projected relative deviation $\sigma_{13} = 1/[R]_{13}$ originating in the negative, and the projected relative deviation $\sigma_{23} = 1/[R]_{23}$ originating in the positive follow from Eq. (40).

$$\begin{aligned} \Upsilon_{13} &= c\bar{\psi}_3\delta_{23}^{\frac{3}{2}}/[R]_{13} \\ \Upsilon_{23} &= c\bar{\psi}_3\delta_3^{\frac{3}{2}}/[R]_{23} \end{aligned} \qquad (41)$$

and their ratio is:

$$\Upsilon_{13}/\Upsilon_{23} = (\delta_{23}/\delta_3)^{\frac{3}{2}}([R]_{23}/[R]_{13}) \qquad (42)\dagger$$

The constants c and the signal flux ratio cancel out because they refer to the common signal flux from the projection lens (see Fig. 56). The geometric sum $\Upsilon_p = (\Upsilon_{13}^2 + \Upsilon_{23}^2)^{\frac{1}{2}}$ can be expressed by the ratio

$$\Upsilon_p/\Upsilon_{23} = \left[\left(\frac{\Upsilon_{13}}{\Upsilon_{23}}\right)^2 + 1\right]^{\frac{1}{2}} \qquad (43)\dagger$$

Analogous to Eq. (41), Υ_p can also be expressed by

$$\Upsilon_p = c\bar{\psi}_p\delta_p^{\frac{3}{2}}/[R]_p \qquad (44)$$

Forming the ratio Υ_p/Υ_{23} with Eqs. (44) and (41) eliminates the constants c and the identical flux values $\bar{\psi}_p = \bar{\psi}_3$, and yields an expression for *the equivalent sampling aperture* δ_{p_o} *for the total relative deviation* in known quantities:

$$\delta_{p_o} = \left[\frac{[R]_p}{[R]_{23}}\frac{\Upsilon_p}{\Upsilon_{23}}\right]^{\frac{2}{3}}\delta_3 \qquad (45)\dagger$$

The corresponding equivalent passband is: $N_{e(p)} = 1.08/\delta_{p_o}$. The amplitude ratios and the equivalent aperture of the standard motion picture process are listed in Table X. In photographic processes the values N or N_e are usually measured in lines per millimeter whereas lengths or aperture diameters (δ) are measured in microns. A conversion factor of 10^3 appears, therefore, in the quantities in Table X.

It is seen from Table X that the relative amplitudes and equivalent passbands vary somewhat with the film

† The $[R]$ values in these equations may be replaced by the corresponding $[R]^*$ values computed for $\gamma_3 = 1$ which cancels out in these ratios.

density. A set of conditions is shown in Fig. 59 for $D_2 = 0.91$. The amplitude characteristic of the deviations from the negative film (curve N) is given by the combination of 3 + 4 in Table IX. The relative amplitude scale is indicated by the value $\Upsilon_{13} = (4.4/4.5)\ \Upsilon_p$ at $N = 0$. The response characteristic (P) for the deviation from the positive film is determined by the projection lens and copied from column 4 of Table IX. Its initial amplitude is $\Upsilon_{23} = \Upsilon_p/4.5$. The geometric addition $N + P$ of the composite deviations from both films shows the negligible effect of the fine-grain positive on the total deviation at the density $D = 0.91$. The aperture effect of the positive film can be demonstrated visually by photomicrographs of the grain structure in 5302 positive film containing a print of the grain structure of Plus X negative film. Print 1 of Fig. 60 is a sharp copy of the composite grain structure. The large white patches represent integrated grains from the negative film which average in diameter the equivalent resolving aperture ($\delta_2 = 25\mu$) of the positive film. Prints 2 and 3 are out-of-focus projections with lens apertures $\delta_3 = 5\mu$ and $\delta_3 = 10\mu$, respectively, demonstrating the integration of the fine-grain structure of the positive film by an excellent projection lens. The negative grain in print 3 is, hence, integrated by an equivalent aperture of 27-μ diameter (Eq. (30)) while the positive grain is integrated by a 10-μ aperture. A composite print 3a was made from a positive copy of the negative plate projected with the equivalent aperture $\delta_{13} = 26.6\mu$ and the fine-grain positive placed over and spaced from the copy of the negative so that it was projected simultaneously with an equivalent aperture $\delta_3 = 13\mu$ to approximate artificially the conditions of print 3. The similarity of the grain structures in prints 3 and 3a is apparent.

The use of positive film with a resolving power and grain structure equal to that of the negative film has a more noticeable effect on the total deviation in the projected positive print. Table XI was computed for the same relations of densities and gammas as listed in Table X, but the Plus X film was replaced by 5203 fine-grain negative film and a better projection lens was used. This combination of two fine-grain films represents a condition used for television recording on 16mm film. The signal-to-deviation ratios $[R]^*_p$ computed for a projection lens with an equivalent aperture $\delta_3 = 16.5\mu$ are only slightly better in the highlight range (see curve 3 in Fig.

Table XI. Signal-to-Deviation Ratios for 5203 Fine-Grain Negative Film Copied on 5302 Fine-Grain Positive Film and Sampled by a 16.5-Micron Aperture ($\dot{\gamma}_3 = 1$).

$\delta =$	30μ	30μ*	16.5μ	30 & 16.5μ				
D_2	$[R]_1$	$[R]^*_{13}$	$[R]^*_{23}$	$[R]^*_p$	$\Upsilon_{13}/\Upsilon_{23}$	Υ_p/Υ_{23}	$\delta_{Po}(\mu)$	$N_{e(P)}$
2.77	100	60	14.3	13.9	0.32	1.05	17.2	63
2.3	62	33.5	16	14.4	0.645	1.19	18.8	57.5
2.1	58	30	16.8	14.7	0.77	1.26	20	54
1.9	52	26	17.6	14.5	0.91	1.35	20.3	53.2
1.6	48	24	19.3	15	1.09	1.48	21.8	49.5
1.35	44.4	23.5	20.9	15.6	1.2	1.56	22.5	48
0.91	40	25.5	25.8	18.2	1.365	1.69	23.4	46.2
0.6	36.6	30	32.5	22.0	1.46	1.77	23.8	45.5
0.4	34	38	40.6	27.8	1.44	1.75	23.5	46
0.27	32.4	51	51.0	35.4	1.35	1.68	22.5	48
0.19	32	80	65	50.6	1.1	1.48	22	49

* Negative sampled by $\delta_2 = 25\mu$ in cascade with $\delta_3 = 16.5\mu$, equalling $\delta_{23} = 30\mu$.

57a) because they refer to a higher equivalent passband $\mathcal{N}_{e(p)}$.† Amplitude distribution and equivalent passbands are shown in Fig. 61. It is pointed out that this comparison is made on the basis of *unit areas* and does not refer to actual frame sizes!

A reduction print of a 35mm Plus X negative on 16mm 5302 positive film has substantially the same relative deviation per unit area as the above fine-grain process. The number of grains per *unit* area in the reduced negative image is increased by the ratio of the frame areas, and $[R]^*_{13}$ increases, therefore, by the linear reduction factor 15.7/7 = 2.25. In comparison, the change from Plus X to 5203 fine-grain negative film increases $[R]_{13}$ 2.6 times (see Fig. 52). In the reduction print the sampling aperture of the negative film, however, is increased by the printer lens which reduces the passband and decreases the difference in $[R]$-values.

The effect of the quality of the projection lens on the total relative deviation is readily computed by the above method and is illustrated in Fig. 62 for three values of the sampling aperture δ_3 of the lens. When δ_3 is large compared to the effective aperture δ_2 of the positive film, the deviations from the negative film are predominant ($[R]_{13} \ll [R]_{23}$). When the lens quality is increased ($\delta_3 < \delta_2$) the deviations ($1/[R]_{23}$) from the positive film increase because of the increased passband and exceed the deviations from the negative film which approach a fixed value determined by the passband of δ_2. The relative amplitudes and line number spectra of ψ_{13} and ψ_{23} for D_2 = 0.91 are approximated by exponential aperture characteristics (Fig. 44, Part I).†

5. Signal-to-Deviation Ratios and Gamma of Motion Picture Film for Television Recording

Television images are recorded on film for the purpose of storing video signals for use at a later time. To obtain a perfect duplicate of the original signals, the overall transfer characteristic of the system components involved in

† It is cautioned that equal $[R]_p$-values do not necessarily indicate equal visibility of the grain structure.

† The line number scale is established with Eq. (19) and Table VII.

$$\mathcal{N}\delta_{ex} = \mathcal{N}_e/1.6$$

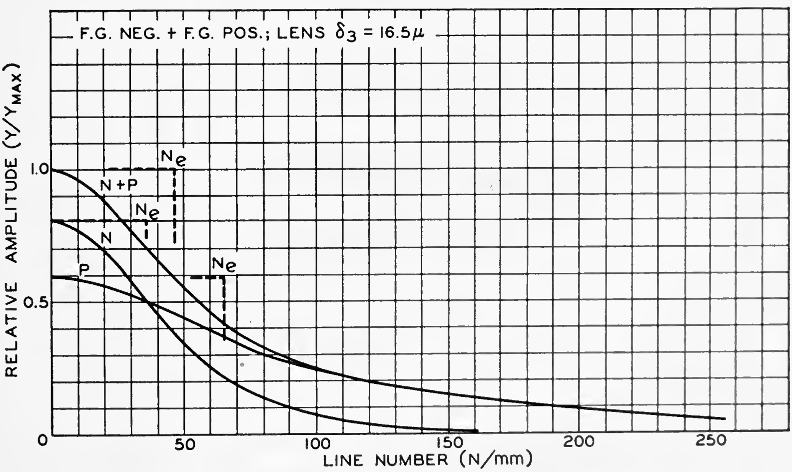


Fig. 61. Sine-wave spectrum of deviations in fine-grain motion picture process.

the recording and reproducing process from signal to duplicate signal must be linear. This requirement implies that the product of the point gammas of the system components must equal unity at any signal level as stated by

$$(\dot{\gamma}_{v_1}\dot{\gamma}_{k_1})(\dot{\gamma}_1\dot{\gamma}_2)(\dot{\gamma}_c\dot{\gamma}_{v_2}) = 1 \qquad (46)$$

The first product contains the gammas of video amplifier ($\dot{\gamma}_{v1}$) and associated recording kinescope ($\dot{\gamma}_{k1}$), the second term contains the gammas of the negative and positive films used in the photographic process (neglecting lens flare), and the third term contains the gammas of the reproducing camera tube ($\dot{\gamma}_c$) and its associated video and correction amplifier ($\dot{\gamma}_{v2}$). The combination of a television process of constant overall gamma with a motion picture process of constant overall gamma has many advantages as pointed out in Part I.

The overall transfer characteristic of the motion picture process most suitable for video recording has a constant gamma ($\gamma_1\gamma_2$) and a relatively short density range ΔD_2 (see Table III, Part I). It is of interest to determine the effects of varying gamma and density range of the negative film on the signal-to-deviation ratio $[R]_p$, when the product $\gamma_1\gamma_2$, the exposure range of the negative, and consequently the density range ΔD_2 in the positive film are maintained constant. To prevent distortion, it is required to operate on film characteristics having adequately long constant-gamma sections. For a numerical evaluation, the values given in Fig. 52 for fine grain 5203 and 5302 film will be assumed.

Given an exposure range $\Delta \log E_1 =$ 1.3 of the negative and a density range $\Delta D_2 = 1$ in the positive, the product of the film gammas must have the value $\gamma_1\gamma_2 = 1/1.3$, which can be obtained, for example, with the values $\gamma_1 = 0.77$, $\gamma_2 = 1$, or $\gamma_1 = 1.54$, $\gamma_2 = 0.5$. Densities and signal-to-deviation ratios for these two conditions are listed in Table XII. The signal-to-deviation ratios $[R]^*_{23}$ of the positive film remain the same for both conditions because they are determined by the fixed density range ΔD_2. The values $[R]^*_{13}$ transferred from the negative to the positive, however, change in proportion to $1/\gamma_2$ and as the square root of the negative

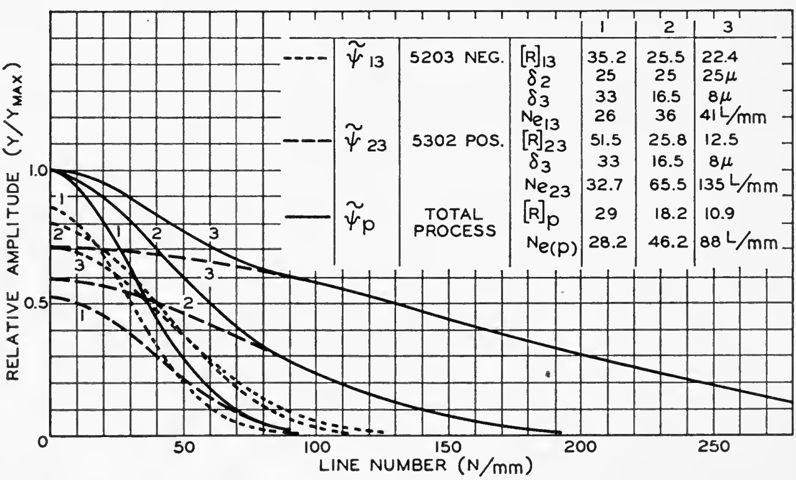


Fig. 62. Effect of projection lens quality on sine-wave spectrum of deviations in fine-grain motion picture process.

Table XII. Signal-to-Deviation Ratios for Constant-Gamma Films (Fine-Grain 5203 and 5302) With Good Lens ($\delta_3 = 19\mu$, $\gamma_3 = 1$).

				δ (microns):	30	30	19	30 & 19				30	19	30 & 19
Log E_1	D_1^*	Log E_2	γ_2	D_2^*	$[R]_1$	$[R]^*_{13}$	$[R]^*_{23}$	$[R]^*_p$	D_1^*	D_2^*	γ_2	$[R]^*_{13}$	$[R]^*_{23}$	$[R]^*_p$
0	0.25	1.25	2	2.25	87.5	43.7	18.6	17.1	0.25	2.25	1	87.5	18.6	18.2
	0.50	1.0	2	1.75	62	31	21.2	17.5	0.75	1.75	1	50	21.2	19.6
	0.75	0.75	2	1.25	50	25	25	17.7	1.25	1.25	1	39	25	21
	1.0	0.5	2	0.75	44	22	32	18.1	1.75	0.75	1	33	32	23
1.3	1.25	0.25	2	0.25	39	19.5	56	18.4	2.25	0.25	1	29	56	25.8
	($\gamma_1 = 0.77$)			$\Delta D_2 = 2$					($\gamma_1 = 1.54$) $\Delta D_2 = 2$					

			δ (microns):	30	30	19	30 & 19				30	19	30 & 19
Log E_1	D_1^*	D_2^*	γ_2	$[R]_1$	$[R]^*_{13}$	$[R]^*_{23}$	$[R]^*_p$	D_1^*	D_2^*	γ_2	$[R]^*_{13}$	$[R]^*_{23}$	$[R]^*_p$
0	0.25	1.25	1	87.5	87.5	25	24	0.25	1.25	0.5	175	25	24.8
	0.50	1.0	1	62	62	27.8	25.3	0.75	1.0	0.5	100	27.8	26.8
	0.75	0.75	1	50	50	32	27	1.25	0.75	0.5	78	32	29.6
	1.0	0.5	1	44	44	39	29.1	1.75	0.5	0.5	66	39	33.5
1.3	1.25	0.25	1	39	39	56	32	2.25	0.25	0.5	58	56	40.4
	($\gamma_1 = 0.77$) $\Delta D_2 = 1$							($\gamma_1 = 1.54$) $\Delta D_2 = 1$					

density D_1^*. The values $[R]^*_{13}$ and $[R]^*_p$ increase, therefore, when the *negative gamma* increases. This relation is equally true for other values of the density range ΔD_2^* in the positive print as shown by Table XII and the graphs in Fig. 63 for $\Delta D_2 = 2$ for two conditions $\gamma_1 = 0.77$, $\gamma_2 = 2$, and $\gamma_1 = 1.54$, $\gamma_2 = 1$. The contribution by the positive film deviations becomes relatively larger when the negative gamma is increased, and the curve of $[R]^*_p$ for the process cannot improve beyond the limit set by $[R]^*_{23}$. After conversion into video signals the signal-to-deviation ratios $[R]^*_p$ of the photographic process are modified by the gamma of the television camera chain to the value

$$[R]^*_p{}' = [R]^*_p/(\dot{\gamma}_c\dot{\gamma}_{v_2}) \qquad (47a)$$

It is emphasized that this expression does not take into account the aperture effects of television components and is, therefore, not an electrical signal-to-noise ratio. For a given camera chain, however, the values $[R]^*_p{}'$ have a direct relation to the electrical fluctuation signals caused by the photographic process and Eq. (47a) can, hence, be used to indicate the relative performance of the photographic link in the recording system. According to Eq. (46) the product $1/(\dot{\gamma}_c\dot{\gamma}_{v_2})$ may be replaced by $K(\dot{\gamma}_1\dot{\gamma}_2)$ because the product $(\dot{\gamma}_{v_1}\dot{\gamma}_{k_1})$ associated with the value $[R]^*_p$ at any one value of density D_1 will be left unchanged and may, hence, be replaced by a factor K. This substitution results in the more useful expression

$$[R]^*_p{}' = [R]^*_p K\gamma_1\gamma_2 \qquad (47b)$$

which shows the influence of varying the product $\gamma_1\gamma_2$ of the photographic process on the signal-to-deviation ratio obtained in the video channel. Table XIII lists the values obtained by Eq. (47b) for the four conditions shown as curves 1 to 4 in Fig. 63.

Inspection of Table XIII shows that curves 1 and 3 give higher signal-to-deviation ratios $[R]^*_p{}'$ at highlight signal levels than curves 2 and 4 indicating preference for a high negative gamma ($\gamma_1 = 1.54$). At the black level the longer range positive films 3 and 4 are preferred because the value $[R]^*_p$ on curves 1 and 2 are seriously limited by deviations $[R]_{23}$ contributed by the positive film (see Table XII). A 16mm positive film having a finer grain than the 5203 negative ($[R]^*_{23}$ increased by at least a factor of two) is, therefore, desirable for video recording because it practically eliminates the limitation by $[R]^*_{23}$. Good ratios $[R]^*_p$ in the high- and medium-transmittance range of the motion picture film are most important to reduce the visibility of film grain.

When a sharp kinescope image with separated raster lines is recorded on film the equivalent rectangular cross section $s = V/N_{e(a)}$ of the lines in the negative film may be smaller than the raster line distance V/N_r, where $N_{e(a)}$ = cascaded aperture passband of kinescope,

Table XIII. Signal-to-Deviation Ratios of Photographic Constant Gamma Processes for Video Recording.

Curve No. in Fig. 63	$[R]^*_p$		$[R]^*_p{}'$ (Eq. (47b))			
	$D_2^* = 0.25, 1.25, 2.25$		Highlight level ($D_2^* = 0.25$)	Black level ($D_2^* = 1.25, 2.25$)	$\gamma_1\gamma_2$	ΔD_2^*
1	40.4 24.8		31	19.1	0.77	1
2	32 24		24.6	18.5	0.77	1
3	25.8	18.2	39.8	28	1.54	2
4	18.4	17.1	28.4	26.2	1.54	2

camera lens and negative film; V = vertical frame dimension, and N_r = number of raster lines in V (see Part I, Sec. B8, p. 160). In this case the exposed frame area and the number of utilized grains in the negative film are reduced by the factor $K_1 = N_r/N_{e(a)}$ resulting in a reduction of the normal signal-to-deviation ratio $[R]_1$ from the negative to $[R]_1\sqrt{K_1}$. After transfer of the image to the positive film the cascaded value $N_{e(a)}$ includes the aperture of the positive film. The new factor K_2 changes, therefore, the ratio $[R]_2$ from the positive which becomes $[R]_2\sqrt{K_2}$, but it does not alter the above value $[R]_1\sqrt{K_1}$. The signal-to-deviation ratios in a video film-recording process have normal values when K_1 and K_2 are equal or greater than unity, but they are reduced to lower values than given in the previous discussion when the factors K_1 and K_2 are smaller than unity.

The conditions for optimum signal-to-deviation ratios may be summarized as follows:

(a) In both negative and positive films the minimum densities should be as low as possible and the density ranges (ΔD) should be as large as possible without conflicting with the operating requirements of the television system which limits the maximum density range ΔD_2 in the positive and makes a constant product $\gamma_1\gamma_2$ desirable for adequate exposure latitude. The value ΔD_2 may be varied within wide limits when the positive film has a substantially finer grain than the negative.

(b) The negative gamma should be as high as possible, a high gamma being obtained by selection of a film type with a larger grain number and not by over-development of a low-gamma film which may give a higher gamma by increasing the grain size. In practice the requirement for high gamma is tempered by the decreasing exposure lattitude, a short range $\Delta \log E_1$ permitting, in general, a higher negative gamma.

(c) The positive film should have a finer grain than the negative film (by a factor of two or more).

6. Luminance Fluctuations and Optical Passbands of Motion Pictures

Twenty-four different phases of the deviations in the positive film are shown every second in a motion picture projection. The static deviations in the film frames are transformed into luminance *fluctuations* and because of the persistence of vision, the grain structures in successive fields are integrated to some extent by the eye. The deviation ratio $[R]_p$ of the process changes to the optical *luminance fluctuation ratio*

$$[R]_o = s[R]_p \quad (48)$$

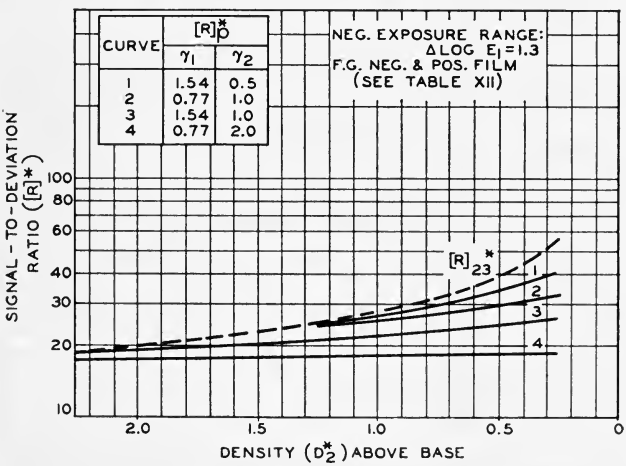


Fig. 63. Deviation characteristics of constant-gamma film process for video recording.

Table XIV. Signal-to-Deviation Ratios ($[R]^*_p$) and Equivalent Passbands ($N_{e(p)}$) of Motion Picture Processes at $D_2 \simeq 1$.

Process	N_{ep}	$[R]^*_p$	$[R]^*_p N_{e(p)}$	$N_{e(p)}$/mm	δ_{p_o}	Components	δ_2
35mm motion picture	370	14.9	5510	23.6	45.9	Plus X, F.G. pos., 4-in. Super Cinephor	(49.5)
16mm motion picture	165	14.9	2460	23.6	45.9	Plus X, F.G. pos., 4-in. Super Cinephor	(49.5)
16mm motion picture(fine-grain)	323	18.2	5910	46.2	23.4	F.G. neg., F.G. pos., High-quality lens	(16.5)
16mm video recording, 20:1 exposure range ($\Delta D_1 = 1.3$)							
$\gamma_1 = 0.77$, $\gamma_2 = 2$, $\Delta D_2 = 2$	285	18.1	5150	40.7	26.5	F.G. neg., F.G. pos., High-quality lens	(19)
$\gamma_1 = 1.54$, $\gamma_2 = 1$, $\Delta D_2 = 2$	312	23	7180	44.5	24.3	F.G. neg., F.G. pos., High-quality lens	(19)
$\gamma_1 = 0.77$, $\gamma_2 = 1$, $\Delta D_2 = 1$	318	29.1	9250	45.5	23.8	F.G. neg., F.G. pos., High-quality lens	(19)
$\gamma_1 = 1.54$, $\gamma_2 = 0.5$, $\Delta D_2 = 1$	353	33.5	11900	50.2	21.5	F.G. neg., F.G. pos., High-quality lens	(19)

The storage factor s depends on the ratio of the effective visual storage time T_s to the frame time T_f and is given in first approximation by

$$s \simeq (T_s/T_f)^{\frac{1}{2}}$$

The value of T_s is left open for a later discussion, but it can be stated that a value s slightly larger than unity is indicated for the conditions in motion pictures.

The foregoing evaluation of deviations in motion picture film has furnished values which refer to an area a specified by the effective sampling aperture of the process. The effective optical passband has been referred to a unit film area (1 sq mm) as expressed by N_e in lines per millimeter. The $[R]$-values for the film and lens combinations shown in Figs. 57 and 63 apply to all frame sizes of motion picture film. The optical "frequency" characteristic and the equivalent passband N_e, however, must be referred to the particular frame size and are obtained from Figs. 59, 61 and 62 by multiplying the unit line number by the vertical frame dimension V in millimeters. (V = 15.7mm for 35mm film and V = 7mm for 16mm film.) *The granularity in a motion picture frame* is determined by the square root of the total grain number in the picture frame area (see Part I). Expansion of the round sampling area a to the frame area $A = VH$ furnishes the *fluctuation ratio with respect to the film frame*

$$[R]_f = s[R]_p(A/a)^{\frac{1}{2}} = s[R]_p(VH/0.25\pi\delta_o^2)^{\frac{1}{2}} \quad (49)$$

and with δ_o from Table VII:

$$[R]_f = s[R]_p N_{e(p)}(H/V)^{\frac{1}{2}}\dagger \quad (50)$$

The signal-to-deviation ratio $[R]_p$ in

† The numerical value computed with the value δ_o from Table VII differs by a few per cent from this value because of the synthesis of the deviation spectrum from the sine-wave response characteristic (see Sec. 3). Equation (49) is exact when the factor given for aperture #3 in Table IV derived for the sampling equivalent $\overline{N_o}$ is used.

this equation still refers to the equivalent sampling aperture (δ_{p_0}) of the process (see Eq. (45)), or its equivalent passband $\mathcal{N}_{e(p)}$. The ratio H/V is the aspect ratio of the film frame. Significant quantities for comparing granularity in 35mm and 16mm pictures are the ratio $[R]_p$ and the line number spectrum (see Figs. 59, 61 and 62), which is indicated by the equivalent passband $\mathcal{N}_e$. Both are needed to define image quality and to predict the appearance and relative visibility of fluctuations to the eye. *The product* $[R]_p\mathcal{N}_{e(p)}$ *combines this information into a single objective figure of merit for the granularity of the process.* The squared value $[R]^2{}_p\mathcal{N}^2{}_{e(p)}$ expresses by definition the number of samples of energy or matter in the equivalent sampling area a (indicated by its reciprocal $\mathcal{N}_e^2$) and is therefore in agreement with fundamental principles. The significant quantities for a number of motion picture processes are summarized in Table XIV.

When the sampling apertures of the various photographic processes are adjusted to have the same value, indicated by equal equivalent passbands $\mathcal{N}_{e(p)}$, the products $[R]_p\mathcal{N}_{e(p)}$ remain substantially unaffected. This adjustment can be made, for example, by a change of the projection lens quality (δ_3) or by adding an additional aperture process (δ_4) in cascade such as the process of vision. Leaving a discussion of the subjective impression of graininess to a later publication, it can be expected that the objective measure of granularity $[R]_p\mathcal{N}_{e(p)}$ will place photographic processes in an order which is in agreement with visual observations.

APPENDIX

STATIC DEVIATION MEASUREMENTS ON PHOTOGRAPHIC FILM

The optical arrangement shown in Fig. 64 is similar, in principle, but not nearly as elaborate as the one used by Jones and Higgins.[2] The sampling aperture is the image of aperture A formed in the film plane by a coated 14-mm objective I. The film sample is mounted on the stage of a Leitz metal-

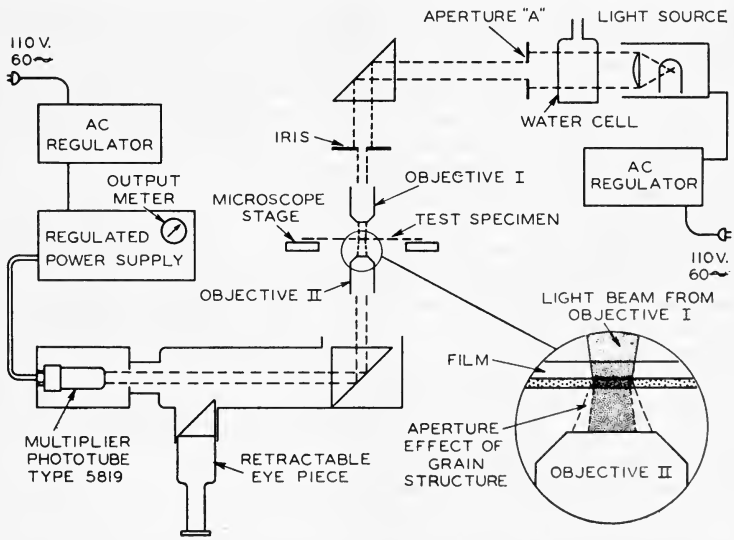


Fig. 64. Apparatus for deviation measurements on photographic film.

lurgical microscope. A second objective II (8mm) below the stage is focused on the aperture image with the film moved out of focus but in the light beam. The film grain is then brought into focus by vertical stage adjustment as observed through the observation eye piece. When the eye piece is retracted the light strikes the photocathode of a multiplier phototube giving an electric current proportional to the total light flux transmitted through the sampling area a on the film. The sampling area a is adjusted by the aperture size A and distance from objective I and measured by removing the phototube and inserting a second ocular to project a magnified image (1000 times) on a ground glass screen (not shown). At any given film density 30 to 60 flux readings are taken along arbitrary cross sections of the film in groups of 10. The readings are averaged and the film is moved to an unexposed area to measure the transmittance ratio τ/τ_0. The deviations $\Delta\tau$ from the mean values are tabulated to determine the rms value $[\Delta\tau]$ and the ratio σ_τ (Eqs. (13) and (33)).

An optical observation of the aperture image with the film in place must be made to check the effective sampling area a. Diffraction or diffusion effects in the developed emulsion introduce an exponential aperture effect which can introduce considerable errors when the sampling aperture is small because it changes the actual sampling aperture to a cascaded value with an effective area larger than the optical image obtained without the test specimen (see insert drawing in Fig. 64). The equivalent aperture diameter of the *developed* film is considerably smaller than that of the undeveloped film (see Table VIII) because of the much higher light absorption by the developed silver grains. The equivalent film aperture increases with emulsion thickness for objectives (I) of shorter focal length and for aperture shapes other than round, and is, in general, proportional to the resolution of the film type. To prevent the aperture error and to satisfy the requirement $\sigma_\tau < 0.1$ (see Eq. (35)) the diameter of the sampling aperture a must be at least three times larger than the equivalent aperture diameter of the developed film type. The sampling apertures used in the measurements reported in this paper fulfill this requirement. Many discrepancies reported in the literature for small sampling apertures are readily explained by the aperture error.

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References

Part I of this paper, "Image structure and transfer characteristics," *Jour. SMPTE, 56:* 131–177, Feb. 1951.

1. O. H. Schade, "Electro-optical characteristics of television systems: Introduction," *RCA Rev., 9:* 5–13, Mar. 1948.
   "Part I — Characteristics of vision and visual systems," *ibid.*, 13–37, Mar. 1948.
   "Part II — Electro-optical specifications for television systems," *ibid.*, 245–286, June 1948.
   "Part III — Electro-optical characteristics of camera systems," *ibid.*, 490–530, Sept. 1948.
   "Part IV — Correlation and evaluation of electro-optical characteristics of imaging systems," *ibid.*, 653–686, Dec. 1948.
2. L. A. Jones and G. C. Higgins, "Photographic granularity and graininess. VII. A microphotometer for the measurement of granularity," *J. Opt. Soc. Am., 41:* 192–200, Mar. 1951. (*This article also gives a list of earlier papers on this subject.*)

Color Negative and Color Positive Film for Motion Picture Use

By W. T. HANSON, Jr.

A color film for use in an ordinary 35mm motion picture camera is described. This film contains colored couplers which, upon development to a negative, lead to three-color negative records which are almost fully corrected. The development procedures and the sensitometric characteristics are described. The spectral-density characteristics of the individual images are included. This film is printed on a color positive film. The spectral-density characteristics of the dye images obtained in the positive, the development conditions and the sensitometric characteristics of the positive are given. The printing may be done on an ordinary continuous contact printer. However, scene-to-scene color-balance changes require more complicated equipment. The sensitometric characteristics of the sound-track image and the method of developing this image are described. The color positive film may also be used for making prints from black-and-white color-separation negatives.

INTEGRAL TRIPACK three-color subtractive films have been in use in the motion picture industry for a good many years. These films include Monopack, Ansco Color, and 16mm Kodachrome in this country, and the Agfacolor negative-positive film in Germany. The present paper describes a new negative color film and a new positive color film for use in making 35mm motion pictures. The negative film has certain features which have not previously been used in the motion picture field.

The Negative Color Film. The negative film is called Eastman Color Negative Safety Film, Type 5247. It contains couplers similar to those used in the Kodacolor process described in 1942.[1] Each coupler is dissolved in an oily liquid which is, in turn, dispersed in an emulsion. The structure of the film is shown in Fig. 1. It can be exposed in an ordinary 35mm motion picture camera. The ASA speed rating of the film is 16 and it is balanced for exposure in daylight or with high-intensity arcs with the Brigham Y-1 filter. Being a negative film, it has somewhat more

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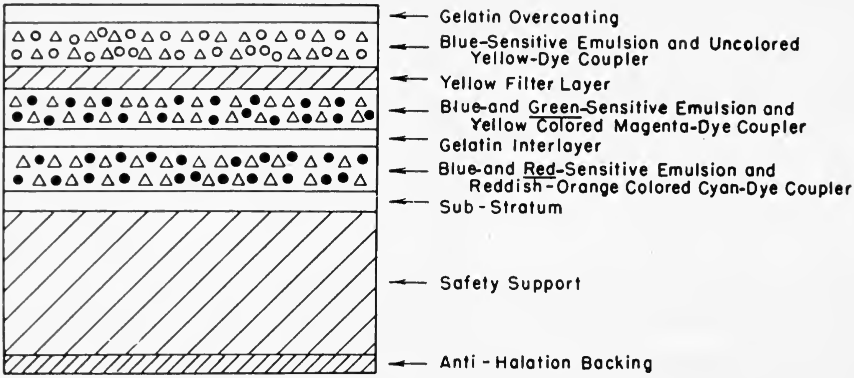

Fig. 1. Schematic cross section of Eastman Color Negative Safety Film, Type 5247.

exposure latitude than most reversal films. One stop overexposure or underexposure can be tolerated with no significant degradation of quality, and two stops overexposure will give a fairly satisfactory result. However, as is the case for practically all color films, the lighting contrast ratio should be from one to two or three and should seldom exceed one to four except where a special effect is desired.

The negative film can be processed in any conventional type of processing machine which has a sufficient number of tanks for the steps that are required, and which has certain tanks that are resistant to the bleaching solution. The processing steps are shown in Table I. The developing agent in the color developer solution is a derivative of *p*-phenylenediamine which does not normally produce "sensitization" in human skin. Its properties in this respect are similar to the well-known Kodak Elon Developing Agent.*

*The exact formulas for the processing solutions must be adjusted for the various processing machines of different design and cannot be specified quantitatively. Information based on the most recent experience is available through the Motion Picture Film Division of the Eastman Kodak Company.

Color Correction With Colored Couplers. The dyes used to form the images in subtractive color processes have absorption characteristics which lead to undesirable results when a color transparency is duplicated or when a color negative is printed to a color positive. The cyan-dye image, for example, which is supposed to absorb only red light, absorbs some of the blue and the green light. The effects of such overlapping absorptions can be minimized or possibly eliminated by the use of separate masks, as described by Miller.[2] However, the procedures involved in using separate masks are extremely tedious. A much more direct and simple method of eliminating the effects of the overlapping absorptions of the dyes is the use of colored couplers.[2–4] Couplers of this type are used in the red- and green-sensitive layers of Eastman Color Negative Film.

The coupler in the red-sensitive layer forms the cyan dye and is colored orange. It has some absorption in the blue and green regions of the spectrum but transmits freely in the red region where the cyan dye absorbs. When this coupler is converted to the cyan dye, the orange color is destroyed. Thus, when a film is exposed and developed, the areas which receive exposure are developed

to a cyan dye, the orange-colored coupler being destroyed. The unexposed areas, in which no development takes place, retain their orange color. Areas of intermediate exposure contain some cyan dye and some residual orange coupler. This results in a cyan negative image and, in the same layer, an orange-colored positive image composed of residual coupler.

The spectral characteristics of various density levels of such an image are shown in Fig. 2. In the red region of the spectrum, successive areas have increasing amounts of density, owing to the increasing amount of cyan dye. In the green and blue regions of the spectrum, successive areas have essentially the same density. Here the increasing densities caused by the increasing amounts of cyan dye are just canceled by the decreasing densities of the decreasing amounts of residual orange-colored coupler. This series of images is expressed in the form of H & D curves in Fig. 3. The densities measured with red light increase with the logarithm of the exposure and give the normal H & D curve of the cyan image. The densities measured with blue and green light, however, are essentially constant at all levels of exposure. This is the desired characteristic of the cyan-dye image.

The green-sensitive layer of Eastman Color Negative Film contains a yellow-colored coupler, which, on development, forms a magenta dye. Here again, exposure and development lead to two images in the layer — a magenta negative image resulting from the destruction of the yellow color in the regions in which exposure and development take place, and a yellow positive image formed by the residual coupler in the unexposed regions.

The spectral-density characteristics of a series of levels of this image are shown in Fig. 4. In the green region of the spectrum, successive areas have increasing green density, owing to the increasing amounts of magenta image dye. In the short-wavelength blue region of the spectrum, successive areas have decreasing density, owing to the decreasing amounts of the residual yellow-colored coupler. However, in the middle of the blue region, at approximately 460 mμ, the decreasing densities of the yellow coupler image are just equal to the increasing densities of the magenta-dye image so that the two images cancel. In the red region of the spectrum, there is practically no density.

These images are expressed in terms of H & D curves in Fig. 5. The densities measured with green light increase with increasing log exposures to form the normal H & D curve. Densities measured with blue light are essentially constant at all levels of exposure. A glance at Fig. 4 will indicate that these blue densities are measured with a filter which has a narrow band of transmission at around 460 mμ.

Spectral-density curves of a series of

Table I. Processing Steps for Eastman Color Negative Film.

Step	Time	Temperature 70 F
Carbonate pre-bath	1–2 min	Not critical
Negative color development	24–27 min	Critical
Stop bath	4 min	Not critical
Water wash	4 min	Not critical
Bleach	8 min	Not critical
Water wash	4 min	Not critical
Fixing bath	4 min	Not critical
Water wash	8 min	Not critical
Wetting agent	1 min	Not critical
Drying	15–20 min	
Lacquering — bead application (both sides)		

Note: Proper development time is a function of agitation conditions and of the particular machine being used. Developer temperature should be controlled to ±0.25 F; other solutions, ±2 F.

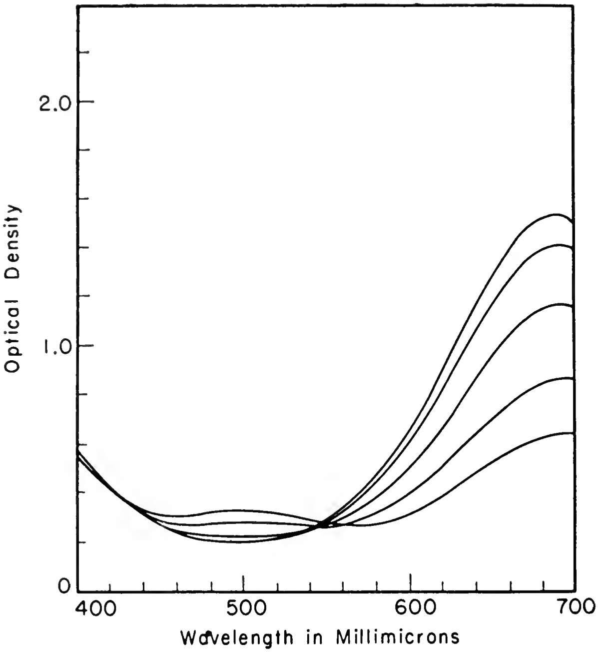

Fig. 2. Spectral-density curves for a series of concentrations of the cyan image of Eastman Color Negative Film.

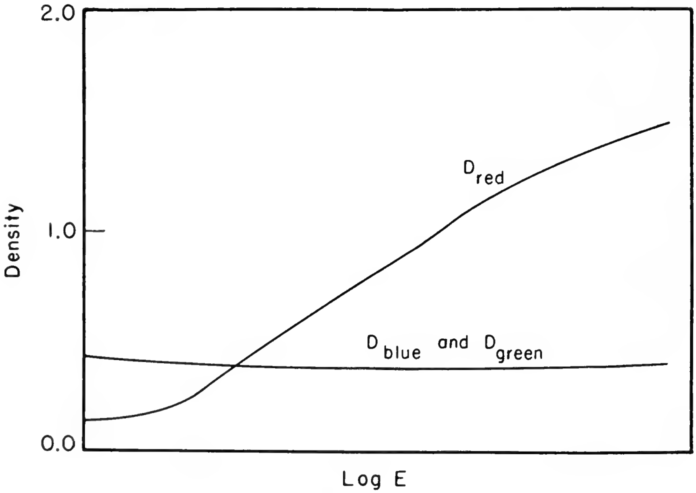

Fig. 3. H &D curves for the cyan image of Eastman Color Negative Film.

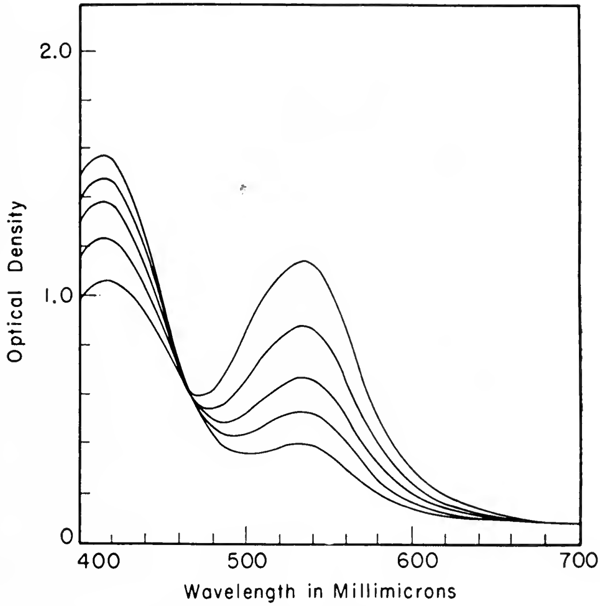

Fig. 4. Spectral-density curves for a series of concentrations of the magenta image of Eastman Color Negative Film.

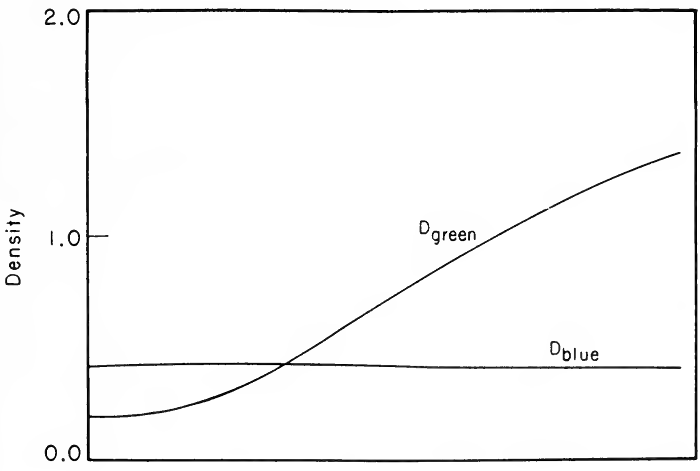

Fig. 5. H &D curves for the magenta image of Eastman Color Negative Film. (Densities to red are insignificant.)

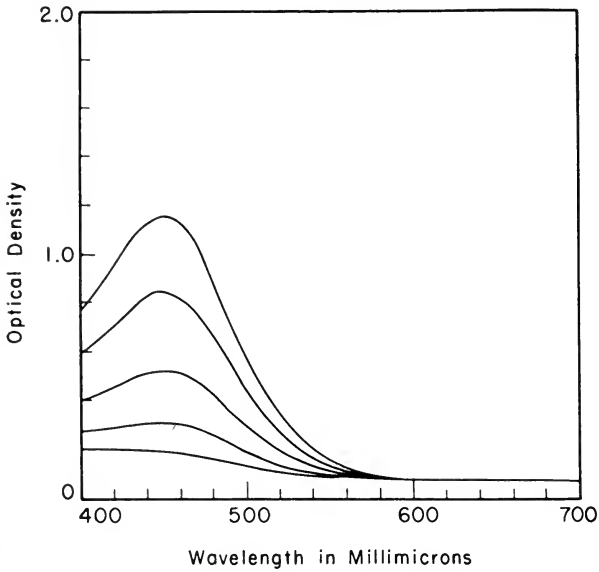

Fig. 6. Spectral-density curves for a series of concentrations of the yellow-dye image of Eastman Color Negative Film.

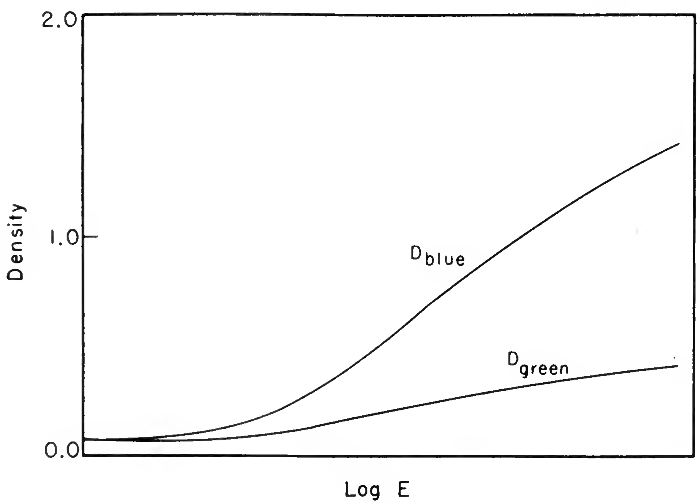

Fig. 7. H &D curves for the yellow image of Eastman Color Negative Film.

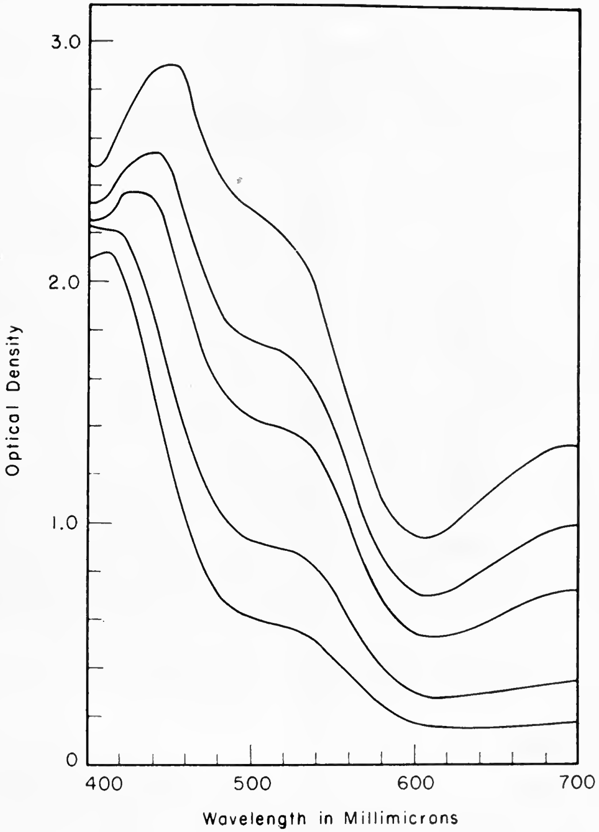

Fig. 8. Spectral-density curves of a series of concentrations of the dyes occurring in the reproduction of a scale of neutrals on Eastman Color Negative Film.

amounts of the yellow-dye image are shown in Fig. 6. In this case, no colored coupler is used. The H & D curves of this image are shown in Fig. 7. The insignificant red densities of the yellow-dye image have been neglected, but there is significant green density, as shown by the curve. It would be desirable to correct this by means of a colored coupler, but to date such correction has not been possible. Such a correction would improve the reproduction of yellows and greens.

The sum of all three of these images is shown in Fig. 8 by the spectral-density curves of the reproduction of a scale of neutrals on Eastman Color Negative Film. Obviously these spectral-density curves do not represent visual neutrals. The reproduction of neutrals is quite orange in color because of the presence of the orange- and yellow-colored couplers. This orange overcast which must occur in all pictures on Eastman Color Negative Film is eliminated in the printing process by the proper sensitization in the print film and the proper selection of light intensity in the red, green and blue regions of the spectrum. However, after such correction has been

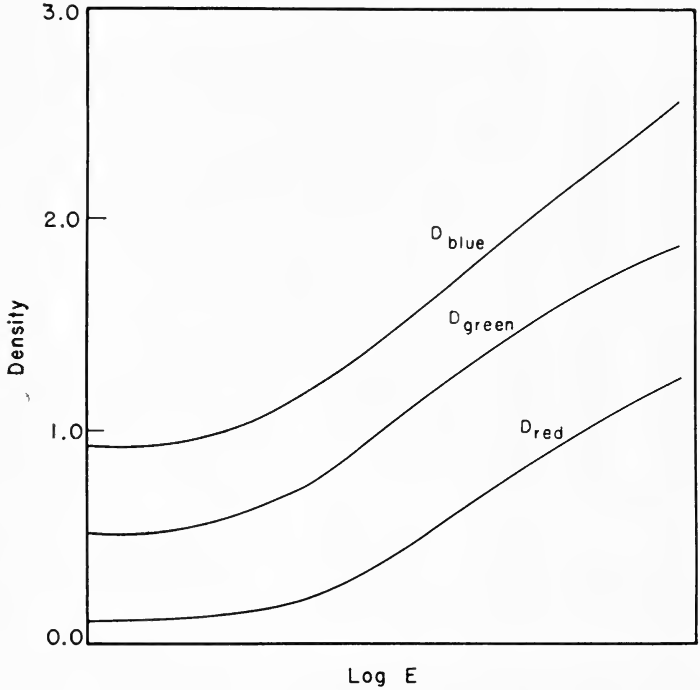

Fig. 9. H &D curves for Eastman Color Negative Film.
Exposure, intensity-scale sensitometer, 1/25 sec;
Illumination, daylight quality;
Density, printing density.

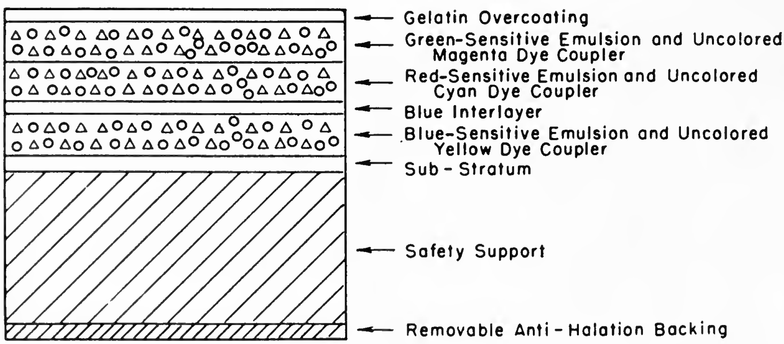

Fig. 10. Schematic cross section of Eastman Color Print Safety Film, Type 5381. (All layers contain a magenta dye.)

made in the printing operation, the final result is free of the defects introduced by the overlapping absorptions of the cyan and magenta dyes in the negative.

The H & D curves for the reproduction of a scale of neutrals on Eastman Color Negative Film is shown in Fig. 9. The three curves represent the densities of the neutral scale as measured with red, green and blue light. These measurements were made through filters with a physical densitometer using a photomultiplier tube with an S-8 sensitive surface. The filters were selected according to the technique described by Williams,[5] with the intention that the densitometer would measure the densities of the image in the same way that the image would print onto the color positive film. Thus, the curves are expressed in terms of printing density. Since these curves are in terms of integral printing densities, they do not represent the separate characteristics of the cyan, magenta and yellow images, but the sum of these three. However, to a first approximation, the red density curve represents the cyan-dye image; the green density curve, the magenta-dye image; and the blue density curve, the yellow-dye image. Here again, the orange-colored overcast of the Eastman Color Negative image is indicated by the high densities to green and the higher densities to blue.

The Positive Color Film. The positive film is called Eastman Color Print Safety Film, Type 5381. It also contains couplers which are dissolved in an oily liquid and dispersed in the emulsions. In this case, however, the couplers themselves are not colored. The structure of this film is shown diagrammatically in Fig. 10. The first emulsion layer is a fairly fast emulsion containing the yellow-forming coupler. It is desirable that this layer be on the bottom, since the yellow-dye image contributes the least to overall picture sharpness and the lower image in a multilayer film is the least sharp. The emulsion is fairly fast so that the negative film with the high blue densities described previously can be printed. The next layer is a blue-dye interlayer. The major purpose of this layer is to absorb red light transmitted by the upper layers. Within all three emulsion layers, light is scattered by the silver halide grains. Scattered red light, as well as direct red light, exposes the red-sensitive layer and thereby causes a decrease in image sharpness. The blue-dye layer underneath the red-sensitive layer absorbs light transmitted by the upper layers and prevents this from being scattered and reflected back to the red-sensitive layer from the bottom layer. There is still some residual scatter in the top two layers which has an effect on sharpness. The next layer is the red-sensitive emulsion

Table II. Processing Steps for Eastman Color Print Film

Step	Time	Temperature 70 F
Carbonate pre-bath	1–2 min	Not critical
Positive color development	12–15 min	Critical
Stop bath	4 min	Not critical
Water wash	4 min	Not critical
Bleach	8 min	Not critical
Water wash	2 min	Not critical
Sound-track development (strip applicator)	10 sec	Not critical
Water wash	2 min	Not critical
Fixing bath	4 min	Not critical
Water wash	8 min	Not critical
Stabilizing bath	1–5 sec	Not critical
Drying	15–20 min	
Edge waxing (both sides)		

Note: Proper development time is a function of agitation conditions and of the particular machine being used. Developer temperature should be controlled to ± 0.25 F; other solutions, ± 2 F.

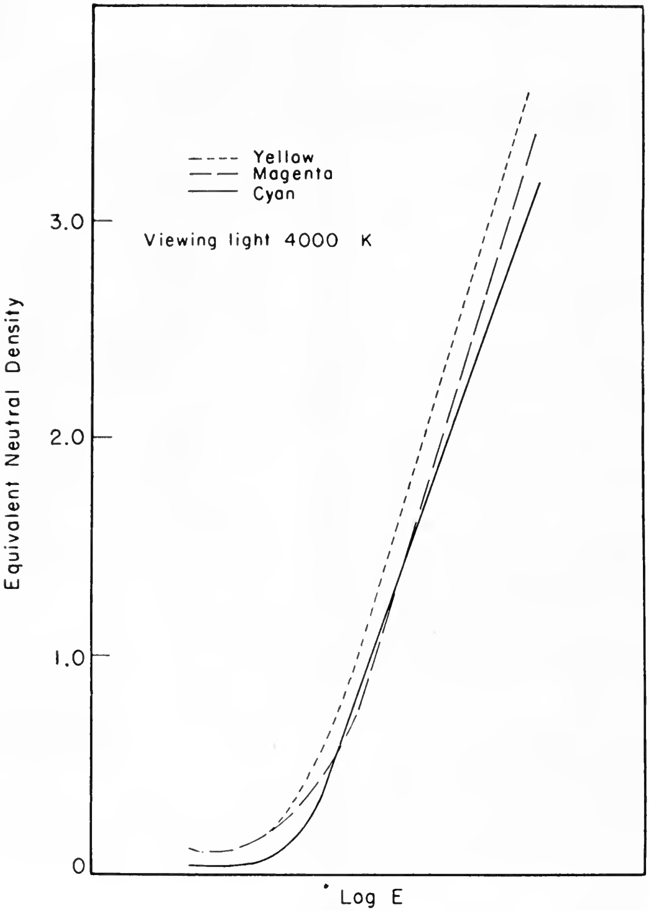

Fig. 11. H &D curves for Eastman Color Print Film. Exposure, intensity-scale sensitometer, 1/25 sec; Illumination, tungsten light plus color-correction filters; Density, equivalent neutral density, calculated from integral density measurements.

containing the cyan coupler. Next is the green-sensitive emulsion containing the magenta coupler. Over this is a gelatin overcoat to protect the film against abrasion. Throughout the entire film is a magenta dye. This prevents green light from being scattered throughout the layers and decreasing the picture sharpness of the magenta-dye image.

The processing steps are shown in Table II.* The developer used for processing the color positive is a deriva-

* The exact formulas for the processing solutions must be adjusted for the various processing machines of different design and cannot be specified quantitatively. Information based on the most recent experience is available through the Motion Picture Film Division of the Eastman Kodak Company.

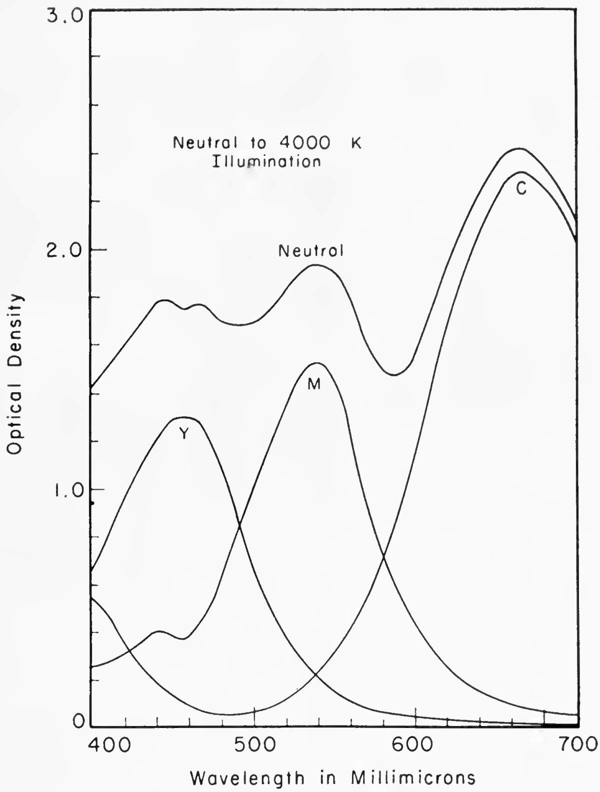

Fig. 12. Spectral-density curves for the cyan, magenta and yellow dyes in Eastman Color Print Film and the neutral they form. Neutral density of 1.72 in 4000 K blackbody illuminant.

tive of *p*-phenylenediamine which is known to produce "sensitization" in human skin. Repeated contact with the developer will lead to "dermatitis." Great care must therefore be exercised in handling this solution.*

After exposure to a step tablet on a sensitometer (the light source being adequately balanced for a particular emulsion), the final processed film may be expressed in terms of the three normal H & D curves of a color film. In order to describe adequately the characteristics of each of the dye images, the densities should be expressed in terms of "analytical" density. For the curves shown in Fig. 11, the densities were read on a physical densitometer through red, green and blue filters and the integral densities converted to equivalent neutral density.[6]

Spectral-density curves of the three image dyes are shown in Fig. 12. These are shown in the amounts which make a neutral density of 1.72 to a blackbody illuminant with a color temperature of 4000 K. Spectral density of the neutral is fairly selective which results in changes in the appearance of the print when the illuminant color is changed. If a print

* Specific precautions which must be followed are available from the Motion Picture Film Division of the Eastman Kodak Company.

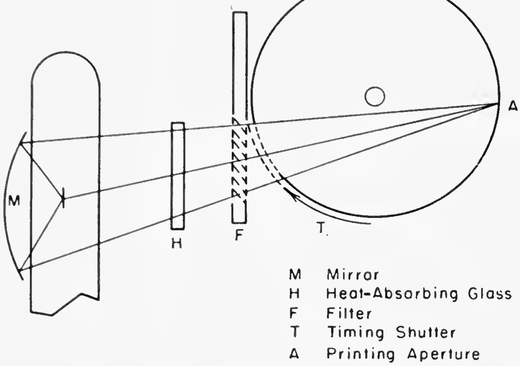

Fig. 13. Schematic illustration of position of filters in light path in Bell & Howell Model D printer.

is properly balanced for arc projection, its appearance will change if a tungsten light source is used.

Printing the Negative to the Positive. As in the case of any integral tripack printing operation, no registration problems are involved in printing Eastman Color Negative Film onto Eastman Color Print Film, and printing can be done on a continuous contact printer. The main requirements are that a light source of sufficient intensity be available and that some means for altering the spectral quality of this light be supplied. Satisfactory results have been obtained using a Bell & Howell Model D printer, with the light source adjusted according to the recommendations of Kunz, Goldberg and Ives.[7] A slot has been cut in the lamphouse casting so that a filter pack may be inserted into the light path at a position shown schematically in Fig. 13. Two pieces of Pittsburgh heat-absorbing glass (No. 2043), 0.1 in. thick, are in the position shown. With a properly exposed negative and a typical print-film raw stock, a 400-w, 115-v lamp operating at 105 v gave satisfactory print density at printer point "12," with the printer operating at the rate of 45 ft/min.

While printing with a continuous tungsten light source, adjusted in color quality by means of color-compensating filters, usually gives a satisfactory print, it does not give the maximum obtainable color quality. The dyes and the colored couplers in the negative have fairly narrow absorption bands so that the color quality obtained in a print is quite sensitive to changes in the sensitivity distribution of the print film or to changes in the spectral quality of the printing light. Reference to Figs. 4 and 6 shows that the blue density characteristics of the yellow and magenta images change appreciably in the region

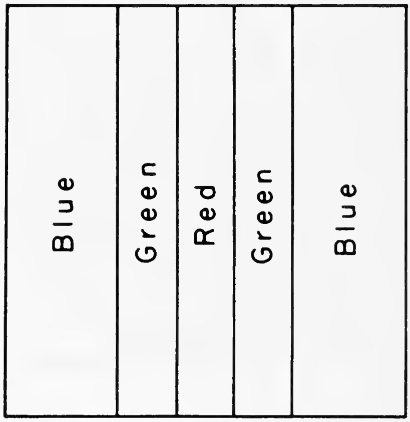

Fig. 14. Filter arrangement for "narrow-band" printing: red, Corning #2408, 1 mm; green, Corning #3486 + #4303, 1 mm; and blue, Corning #5113, 1 mm.

of 410 to 460 mμ. The results obtained in the final print are affected noticeably by changing the quality of the printing light in this region of the spectrum. A Kodak Wratten Filter No. 2B, or similar violet-light absorber, should always be used in the printing operation. Similarly, reference to Figs. 2 and 4 shows that the green density characteristics of the cyan and magenta images vary considerably in the region of 520 to 560 mμ, and the density of the cyan image varies appreciably within the red region of the spectrum. Variations of the quality of the printer light in these spectral regions will lead to varying results.

Better control of the color quality of the print can be obtained if the light source used for printing is composed of three spectral bands in the blue, green and red regions of the spectrum. This can be accomplished by mixing the light transmitted by three filters, for example, by introducing into the light beam on the Bell & Howell Model D printer a filter which is composed of a series of strips of glass as shown in Fig. 14. This filter is placed in the light path in the printer at the same position occupied by the color-compensating filters as shown in Fig. 13. This strip construction of the filter provides uniform illumination at the printing aperture. The position of the filter in the beam and the alignment of the mirror must be critically adjusted in order to ensure uniformity at the printing aperture.

In printing by the technique just discussed, it is possible to use the regular timing shutter on the Bell & Howell printer for introducing density corrections from one scene to the next. However, it is not possible to make changes in the color quality of the illumination between scenes in order to correct the color balance of successive scenes. In motion picture color printing, such "color timing" is necessary. This can be accomplished by the use of three light sources in the optical system of a printer such as the Bell & Howell Model D. This is shown schematically in Fig. 15. The light from each lamp passes through a filter, and then the three light beams are combined at the printing aperture. With this system, the narrow spectral bands of light as described above will be obtained. In addition, the intensity of each of the light sources can be adjusted separately by known means, such as varying the voltage, use of diaphragms, or neutral-density filters, and thereby effect the proper color timing. This type of light source has been described by Bornemann and McKusick.[8]

Eastman Color Print Film can also be printed from color-separation negatives. In this case, the printing must be done in a step printer with adequate registration pins. Negatives obtained from Eastman Multilayer Stripping Negative Safety Film, Type 5249, described by Capstaff,[9] are a typical example. Similarly, separation positives and duplicate separation negatives may be made from Eastman Color Negative and these, in turn, printed onto Eastman Color Print Film or some other color film.

Sound Track. The sound track on Eastman Color Print Film is developed by edge application of a reducing agent* after the rehalogenizing bleach bath. In the color developer, the sound-track and picture images are developed simultaneously to dye and metallic silver. The next step in the process removes all of the unexposed silver halide in both picture and sound-track areas. Following the fixing bath, the bleach bath converts all of the developed silver image to silver bromide. In the sound-

* The exact formulas for the processing solutions must be adjusted for the various processing machines of different design and cannot be specified quantitatively. Information based on the most recent experience is available through the Motion Picture Film Division of the Eastman Kodak Company.

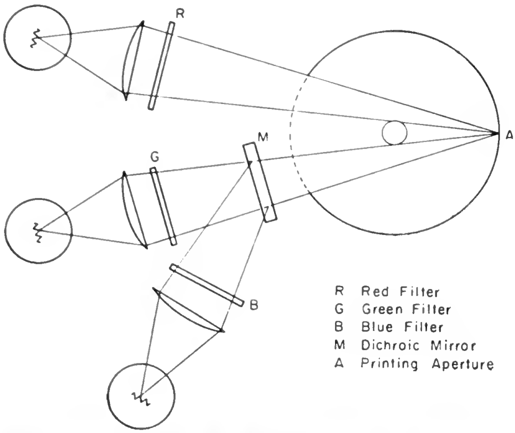

Fig. 15. Schematic illustration of three colored light sources for "color timing" with Bell & Howell Model D printer.

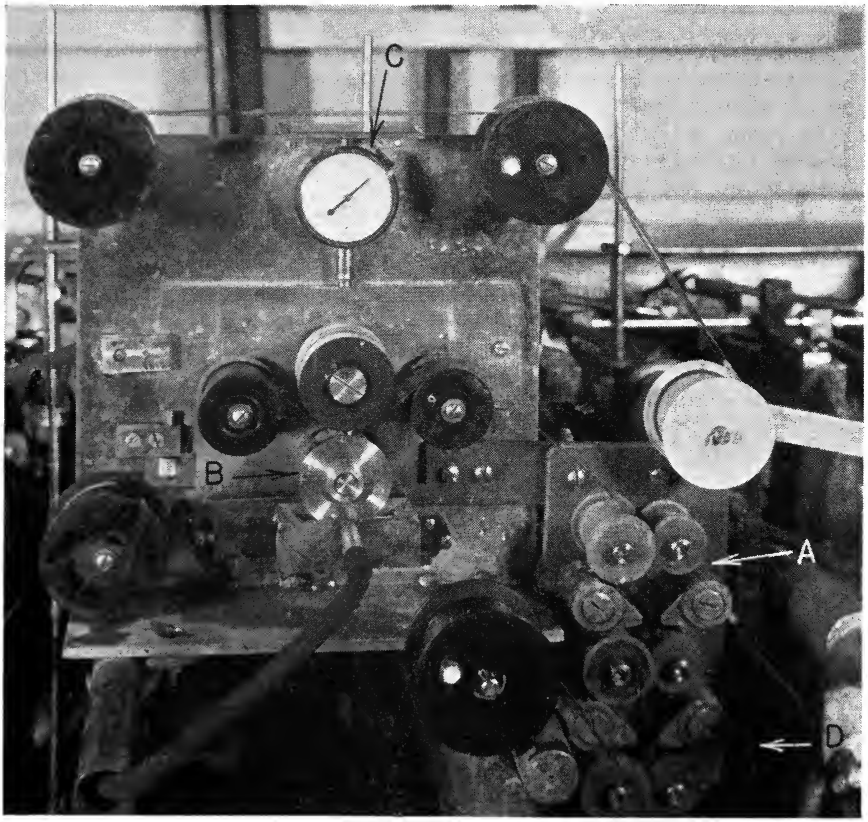

Fig. 16. Sound-track processing: A, air squeegee; B, applicator roller; C, dial indicator for adjusting applicator; and D, film enters wash tank.

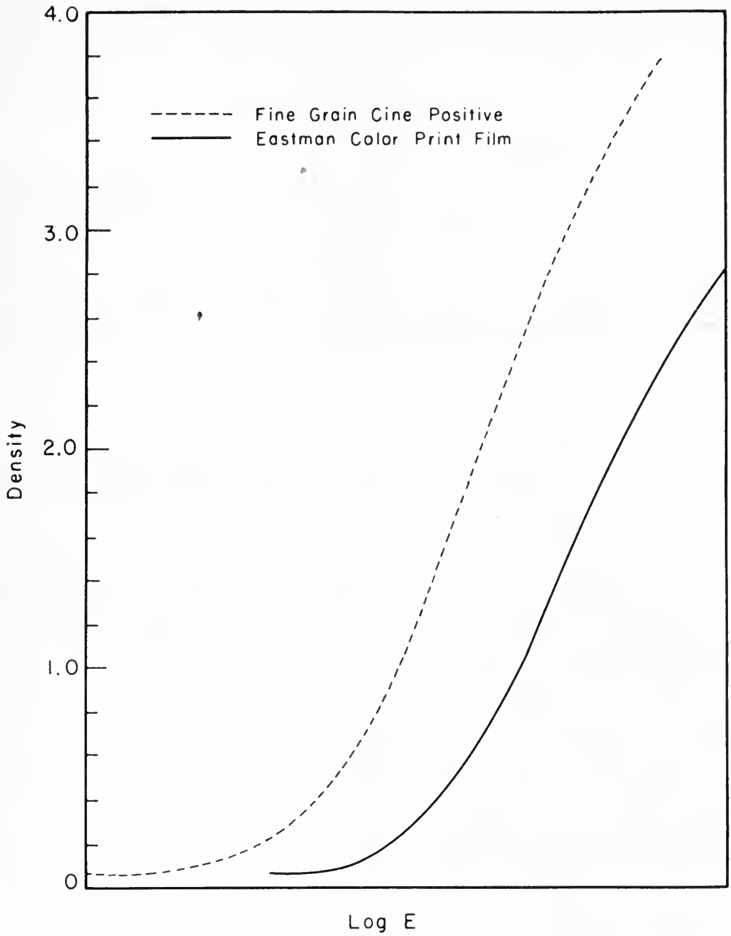

Fig. 17. H & D curves of sound-track images.
Density, ERPI Densitometer with infrared-sensitive cell;
Exposure, Eastman Color Print Film, tungsten light plus color-correction filters for neutral dye image;
Eastman Fine-Grain Cine Positive Film, tungsten light.

track area, this silver bromide is again reduced to metallic silver by an edge-application treatment. The sound track is thus composed of a combined dye and silver image. The edge-application equipment is shown in Fig. 16.

The H & D characteristics of the sound-track image are a function of the color of the light used in exposing the sound track. The highest contrast is obtained if this light is of the color quality which gives a neutral dye image. With such exposure, the density scales of the silver images in the three emulsion layers coincide. Under these conditions, the H & D curve as measured with the infrared-sensitive photocell is as shown in Fig. 17.

An analysis of the characteristics of the sound track on this film has been reported by Evans and Finkle.[10]

References

1. C. E. K. Mees, "Direct processes for making photographic prints in color," *J. Franklin Inst., 233:* 41–50, Jan. 1942.
2. T. H. Miller, "Masking: a technique for improving the quality of color reproductions," *Jour. SMPE, 52:* 133–155, Feb. 1949.
3. W. T. Hanson, Jr., and P. W. Vittum, "Colored dye-forming couplers in subtractive color photography," *PSA Journal, 13:* 94–96, Feb. 1947.
4. W. T. Hanson, Jr., "Color correction with colored couplers," *J. Opt. Soc. Am., 40:* 166–171, Mar. 1950.
5. F. C. Williams, "Objectives and methods of density measurement in sensitometry of color films," *J. Opt. Soc. Am., 40:* 104–112, Feb. 1950.
6. A Report of the Color Sensitometry Subcommittee, "Principles of color sensitometry," *Jour. SMPTE, 54:* 653–724, June 1950.
7. C. J. Kunz, H. E. Goldberg and C. E. Ives, "Improvement in illumination efficiency of motion picture printers," *Jour. SMPE, 42:* 294–314, May 1944.
8. W. Bornemann and W. McKusick, "Illuminating system and light control for 16mm continuous optical printer," *Jour. SMPTE, 54:* 480–482, Apr. 1950.
9. J. G. Capstaff, "An experimental 35mm multilayer stripping negative film," *Jour. SMPTE, 54:* 445–453, Apr. 1950.
10. C. H. Evans and J. F. Finkle, "Sound track on Eastman Color Print Film," *Jour. SMPTE, 57:* 131–139, Aug. 1951.

Printer Control in Color Printing

By C. A. HORTON

The use of an electronic photometer is described for maintaining color and intensity balance in 35mm color printers. Some precautions are given on the use of color-correcting filters and data are provided on the hue shift with temperature and consequent reduction of transmission of certain glass filters.

PRINTING OF motion picture color film brings with it problems which do not arise in black-and-white printing. There, it is usually enough to specify an exposure adequate to produce a definite, easily measured, minimum density in the print. The choice of print stock and processing conditions determine the contrast and tone reproduction from a given negative. In color printing, the quality of the printing light must be controlled even more closely than its intensity. The problem in printing a color film is to adjust and maintain an illumination in the printer gate which will produce a pleasing picture on the theater screen.

These strict requirements are especially true in negative-positive systems where the process gamma of the print stock may approach 3.0. The tolerances which have been found necessary are 0.05 log I on illuminance and 0.02 log I on color changes. Such variations as these, or larger ones, may easily arise from aging of the printer lamp, breaking and, hence, replacement of the heat-absorbing glass, or instability of the absorbers in the color filters being used. An accurate and reproducible method of measuring the quality and intensity of the light in the printer gate is almost indispensable. A convenient photometer for printer control should have a linear scale, a stable zero, a wide sensitivity range and freedom from fatigue, and should be easily fitted into the printer gate.

The use of a photronic cell and a galvanometer for control of 16mm Kodachrome printers has been described to this Society by Aex in 1947.* However, the cell fatigue and the short scale of this instrument make it unsatisfactory for controlling printers using high-gamma materials.

The Densichron† shown in Fig. 1 has been found to satisfy most of the above requirements. It consists of a photocell in an a-c magnetic housing, connected to an a-c amplifier with a logarithmic re-

Communication No. 1351 from the Kodak Research Laboratories, a paper presented on April 28, 1950, at the Society's Convention at Chicago, Ill., by C. A. Horton, Eastman Kodak Co., Kodak Park Works, Rochester 4, N.Y.

* Paul S. Aex, "A photoelectric method for determining color balance of 16-mm Kodachrome duplicating printers," *Jour. SMPE, 49:* 425–430, Nov. 1947.

† Manufactured by the Welch Scientific Company.

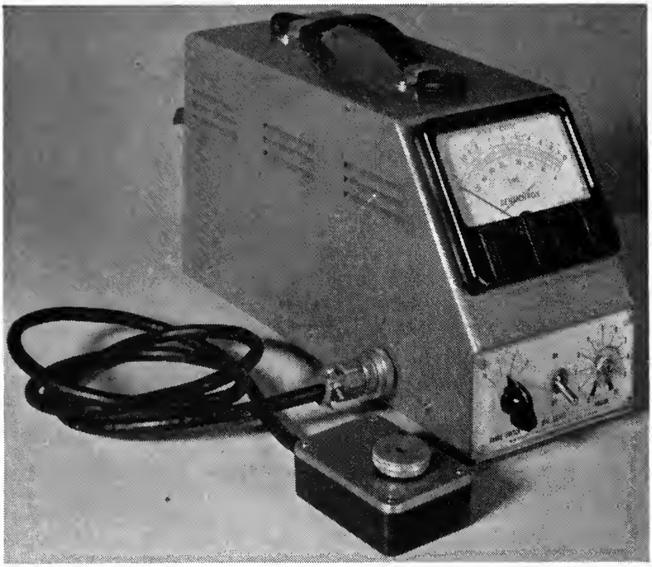

Fig. 1. Densichron and photocell unit.

sponse meter. It is available with either red- or blue-sensitive photocells. The blue cell has been found sufficiently sensitive to measure printer lights through red, green or blue filters. The logarithmic scale is convenient since it may be interpreted directly as log I. Its scale has been found to be linear to better than 0.10 over a log I range of 2.8, as shown in Fig. 2. In all parts of the scale, fatigue is less than 0.01 log I over a three-hour period.

In order to use the instrument as a photometer, some constant source of light is needed as a reference zero. For printer control, the absolute value of the light need not be known. A small battery-operated lamp connected through a milliammeter is adequate or, if a standard sensitometer is available, its direct beam may be used. It is advisable to take readings of the zero of the instrument through tricolor filters in order to detect any relative change in photocell sensitivity. These tricolor filters will be referred to as "analyzing filters." By having such readings recorded it is always possible to adjust the gain to correct for slow drifts in overall sensitivity or an accidental movement of the gain control. The present instrument has been in use six months without showing any change in relative sensitivity.

The choice of tricolor filters for analyzing the light should be determined from the print-film sensitivity and the photocell sensitivity. Ideally, the product of the values of the photocell sensitivity and the transmission of the filters should match the film sensitivity. Since neither of these sensitivities is usually known accurately, it is fortunate that this requirement does not have to be fulfilled strictly.

When printing is being done through filters which produce narrow spectral bands, the analyzing filters may be any set, provided they isolate the same red, green and blue regions of the spectrum as are used in the printer. When printing with white light, or white light modified by color-compensating filters, the choice

is more limited and care must be taken to choose filters which give, with the photocell, a response close to the peak of the film sensitivities. No specific rules for the selection of the filters can be given except that a set is satisfactory if it predicts filter changes that agree with photographic tests. Once a set of filters has been decided upon, it may be used as long as the print material has the same sensitivity distribution.

The most satisfactory filter set found for control of printers using Eastman Color Print Safety Film, Type 5381, was: red — Kodak Wratten Filter No. 70; green — Kodak Wratten Filter No. 16 + No. 61; blue — Kodak Wratten Filter No. 35 + No. 38A. With this set, predictions or transfer of color and intensity balance from one printer to another are correct to 0.02 log E when printing through color-compensating filters. When transferring a balance from this condition to a printer equipped for printing with narrow spectral bands, prediction is correct to about 0.05 log E. The set of narrow-band printing filters used was: red — Kodak Wratten Filter No. 29; green — Kodak Wratten Filter No. 16 + No. 61; blue — Kodak Wratten Filter No. 35 + No. 38A + No.2 A.

In addition to the tricolor filters, the present instrument has a small disk of flashed opal and one of Corning 9780 infrared-absorbing glass $1\frac{1}{2}$ mm thick over the photocell. These are necessary when using the instrument as a color densitometer since the dyes have little density to the infrared. These precautions are probably not necessary when using the photocell as a photometer, but no tests have been made to verify this conclusion.

The Densichron probe containing the photocell is small enough to fit easily in the gate of a Bell & Howell printer. By rotating the probe slowly through a small angle, it is quite easy to get a reproducible maximum intensity reading. In some printers where the probe does not fit in the gate, a curved rod of transparent plastic may be used to conduct the light to the cell. In this case a mechanical guide should be used to locate the probe and rod in the gate, since it is difficult to get reproducible readings when the assembly is held by hand.

When a printing balance is known on one printer, or exposing device, it is frequently necessary to set up the same balance on other printers. By making the appropriate changes in the tricolor readings from the first printer to compensate for differences in speed or time of exposure, these new readings may be set up on the second printer by adjusting the filter pack and timing shutter until the Densichron shows the desired values. This procedure usually brings the printer in balance or so close to it that one photographic test is adequate before starting the printing of full-length pictures.

When a printer test is off balance or shows improper exposure, and density readings on the print, or experience suggests that a change should be made in the printing light, the photometer is more reliable than the catalog densities of the compensating filters. Figure 3 shows spectrophotometric curves of a well-known set of compensating filters. Inspection of these curves shows that the addition of a Kodak Color Compensating Filter CC-50C to the filter pack would seriously disturb the blue and green light balance as well as make the desired correction to the red intensity. By taking red, green and blue photometer readings before and after each filter change, the balance may be corrected exactly to the prescribed set of values. The densities of the complete set of color-compensating filters as read by the Densichron through the filters given are listed in Table I. If measurements are not made by a photometer in the printer gate, these values may be used to estimate the amount of neutral density being introduced in the light beam by the addition of one or more of these filters.

For printer control, daily readings are made through red, green and blue filters

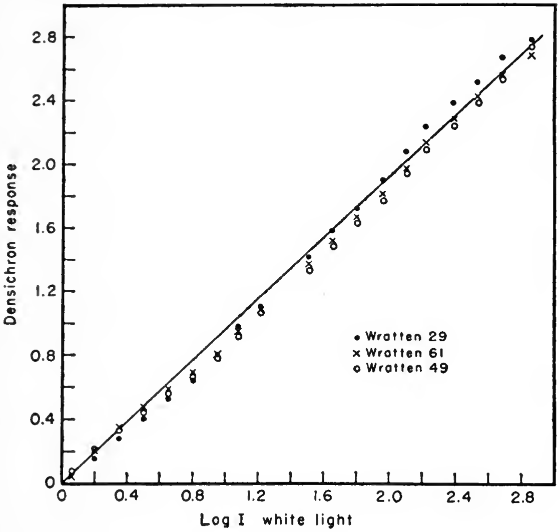

Fig. 2. Linearity of Densichron response.

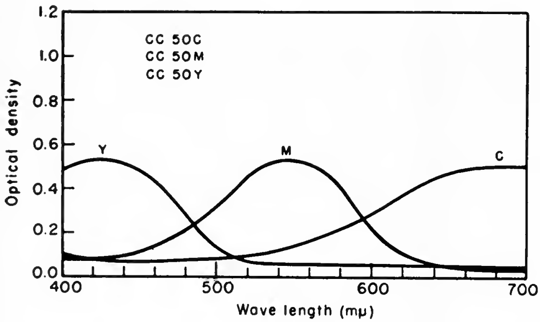

Fig. 3. Spectrophotometric curves of color-compensating filters.

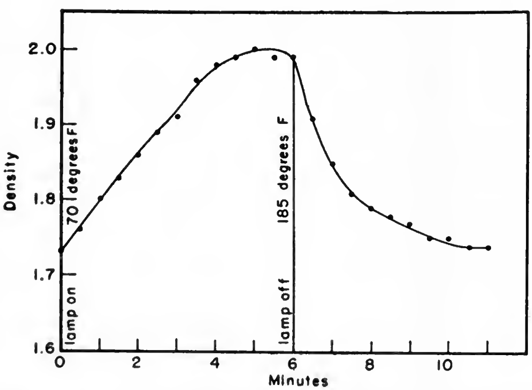

Fig. 4. Density change of red glass filter, Corning No. 2408, Melt 1151, with rise in temperature.

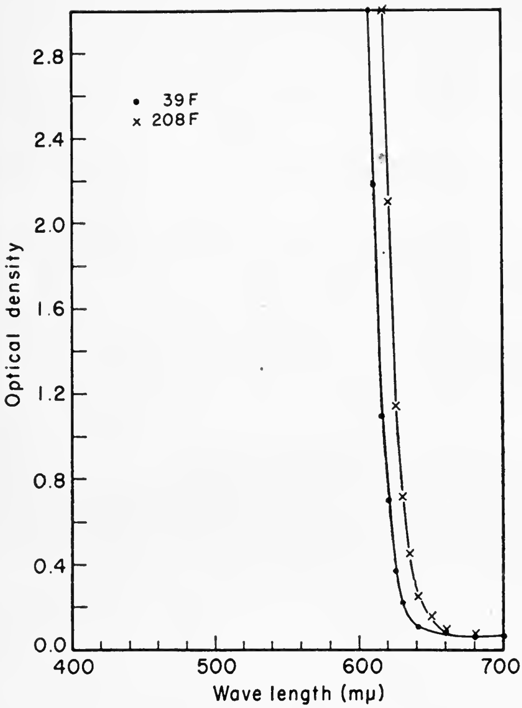

Fig. 5. Shift in the absorption of a red glass, Corning No. 2408, Melt 1151, with change in temperature.

Table I. Densities of Color-Compensating Filters as Measured by the Densichron Through the Tricolor Filters Shown.

	Density to Kodak Wratten Filter		
Designation	No. 29	No. 61	No. 49
CC-05C	0.06	0.04	0.04
CC-10C	0.10	0.04	0.04
CC-20C	0.16	0.05	0.05
CC-30C	0.28	0.07	0.06
CC-40C	0.33	0.08	0.06
CC-50C	0.43	0.09	0.06
CC-05M	0.03	0.06	0.05
CC-10M	0.03	0.10	0.06
CC-20M	0.04	0.16	0.08
CC-30M	0.05	0.28	0.10
CC-40M	0.05	0.31	0.12
CC-50M	0.06	0.47	0.13
CC-05Y	0.03	0.03	0.09
CC-10Y	0.03	0.03	0.12
CC-20Y	0.03	0.03	0.23
CC-30Y	0.03	0.03	0.30
CC-40Y	0.03	0.04	0.37
CC-50Y	0.03	0.04	0.44

of the illuminance in the gate, with and without the printer-balancing filters in position. A comparison of these six readings with those of a previous day's will show whether slow drifts are due to lamp or to filter changes.

Special care must be taken if glass filters are used in the printer, since many of them, particularly the reds and yellows, show a large change in density with temperature. This difficulty has been met with in the use of both Corning No. 2408, Melt 1151, and Corning No. 3384, Melt 600, glasses. The decrease in transmission of the filter as measured by the Densichron may amount to 0.25 log *I* between room temperature and printer-operating temperature. Figure 4 shows a typical curve of density to red light against time for a Bell & Howell printer with Corning No. 2408, Melt 1151, in the beam. The equilibrium temperature reached at about six minutes was 185 F.

This change of density of glass filters is, in general, due to a movement of the absorption edge toward longer wavelengths with increasing temperature. Spectral-density curves for the abovementioned red glass at two different temperatures are shown in Fig. 5. Though inconvenient, this density change with temperature need not reduce the accuracy of the printer control if sufficient time is given for the filters to reach temperature equilibrium before readings of the intensity are made.

When printing through narrow-band filters, such as are used in making duplicate positives from a color negative or printing duplicate positives or negatives on a color print film, the analyzing filters should still be used in addition to the printing filters.

When it is necessary to change to a print emulsion whose relative red, green and blue speeds are different from those of the emulsion previously used, the speed differences determined from sensitometry may be applied directly to the tricolor readings and the filter pack adjusted as indicated by the photometer. Similarly, if densitometry of the negative predicts timing changes to red, green and blue, these may be set up on the printer by means of the photometer.

Desirable Characteristics of 16mm Entertainment Film for Naval Use

By LOWELL O. ORR and PHILIP M. COWETT

Current 16mm release prints are evaluated for sound quality, chiefly by measuring dynamic range. Projection equipment and conditions are described.

We have gathered data on the quality of 16mm entertainment film release prints as we have found it at the Navy Motion Picture Exchange, Brooklyn. By way of comment, and in order to narrow the issues to be presented, we should mention that the 16mm films discussed here are those resulting from reduction of 35mm entertainment films which are circulated to all commercial motion picture theaters, and further, that such 16mm prints are not used by the Navy alone, for equal numbers are used by the Army and Air Force Motion Picture Service, and approximately half as many by the Veterans Administration. In addition, they are being used on commercial ocean liners, and in various foreign countries. We have every reason to believe that in such various uses, exhibition conditions are such that, while not exactly the same as those prevalent in the Navy, they are nevertheless similar to, and in many cases closely approximate, those of the Navy. We would further like to point out that in referring to the producer herein, we mean the actual producer, or releasing distributor, who is the prime contractor under Navy Motion Picture contracts. As such, the prime contractor is solely responsible for the quality of the release prints supplied.

In undertaking our study we felt that good results could be obtained from presenting a systematic analysis of prints as presently released for Navy use. It is not our intention to be hypercritical, but rather, through the relation of our observations, to tend to indicate what the current practice is with respect to the sound quality of 16mm entertainment motion picture release prints.

It is a truism that, before any suitable improvement in quality can ensue, a true picture must be had of the situation existing at this time. That, then, is our motivation: to establish a plateau, you might say, representing the current practice in 16mm film production.

Presented on October 17, 1951, at the Society's Convention at Hollywood, Calif., by Lt. Lowell O. Orr, USN, New York Naval Shipyard, c/o Motion Picture Exchange, Brooklyn 1, N.Y., and Philip M. Cowett, Dept. of the Navy, Bureau of Ships, Washington 25, D.C.

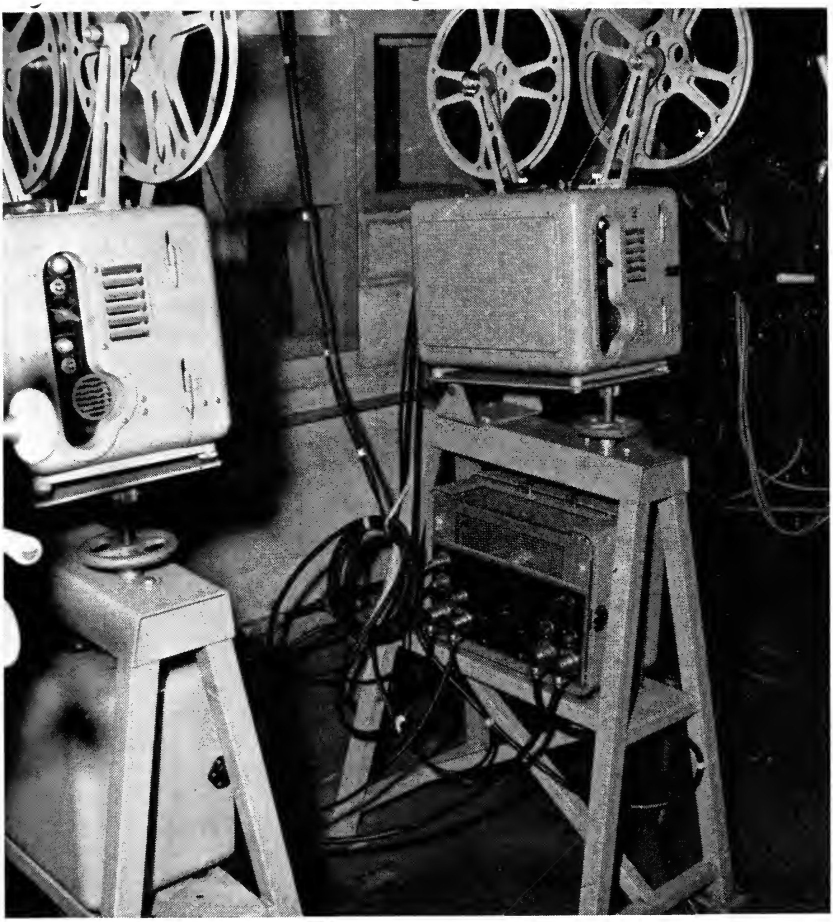

Fig. 1. Standard Navy 16mm IC/QEB projector set.

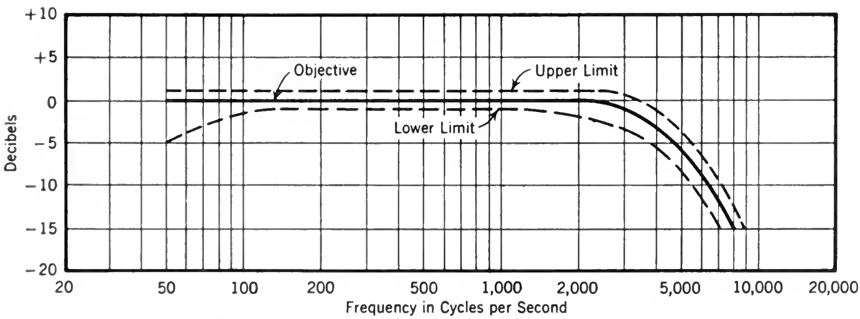

Fig. 2. 16mm sound reproducer electrical characteristic.

Short Form Specification

16mm Review Rooms and Reproducing Equipment

Amplifier Power Output:

10 w, 1% distortion
15 w, 2% distortion
Over passband, 50 to 7000 cycles

Signal-to-Noise Level:

50 db below 10-w level signal from 400-cycle SMPTE standard level film

Frequency Response:

As given in SMPTE recommendations

Uniformity of Scanning-Beam Illumination:

1½ db using SMPTE test film

Flutter:

0.25% peak using SMPTE test film and RCA field-type flutter meter

Fig. 3. SMPTE specifications for reproducing equipment.

We, in the Navy, have problems that are somewhat different from those of the normal user of 35mm entertainment film in that the situation in which the film is reproduced is generally far from desirable. We, for example, exhibit film topside, where high ambient noises caused by exhaust blowers, noises of the ship underway and cross winds, all tend to force a limited dynamic range for optimum intelligibility. A further situation of reproduction which is quite common is that encountered aboard an aircraft carrier, where high ambient noise (80–90 db) results in the net end of masking low-level sequences completely and, unless the print is one of high intelligibility, preventing understanding of much significant dialogue.

As a basis for understanding the data on quality, we should first describe the type of equipment used in the screening room and the exact installation with regard to how the various measurements were made and how our data were obtained. This equipment is the standard Navy 16mm IC/QEB projector set (Fig. 1), manufactured by the De Vry Corporation and designed to conform to the requirements, regarding its frequency-response characteristic (Fig. 2), as set forth by the 16mm Subcommittee on Sound Reproduction (Fig. 3). It has a power-output capacity of 20 w at less than 2% distortion over the passband of frequencies (Fig. 4). The frequency-response and tone-control characteristics of the amplifier are shown in Figs. 2, 5 and 6. Similarly, the portable loudspeaker frequency-response characteristics are shown in Fig. 7.

In order to evaluate prints as to dynamic range, we utilized a second amplifier which was bridged directly across the sound output from the two projector sound heads. The function of this second amplifier was to operate the volume-level indicator which is incorporated in a still projector and is

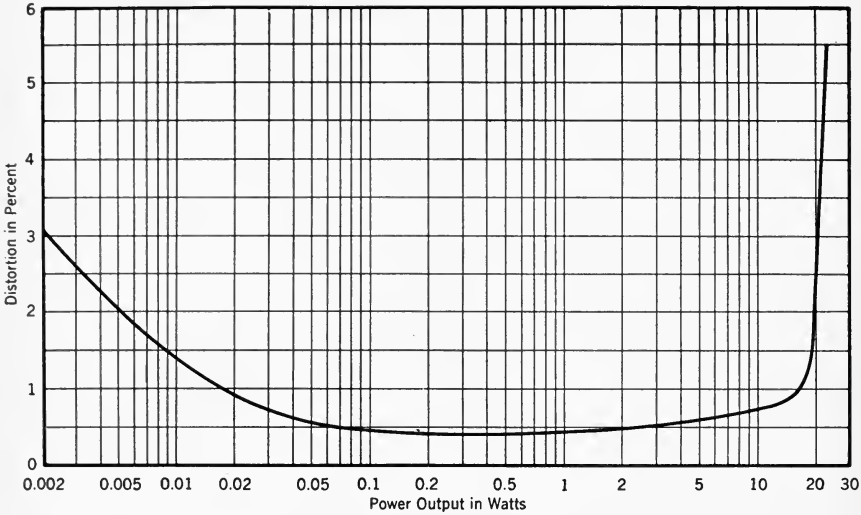

Fig. 4. Amplifier total harmonic distortion versus power output (frequency range 100 cycle/sec to 5000 cycle/sec).

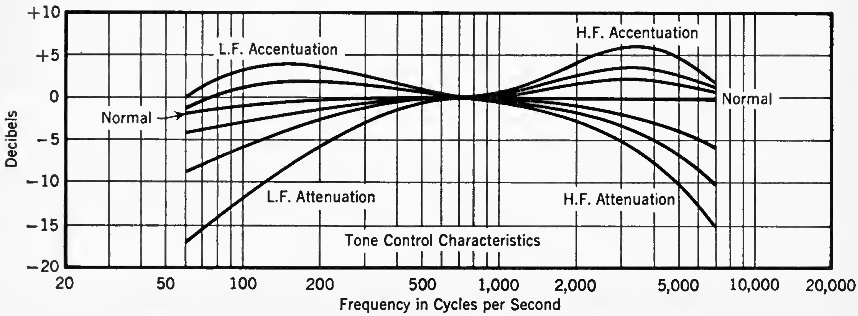

Fig. 5. Amplifier tone control characteristics.

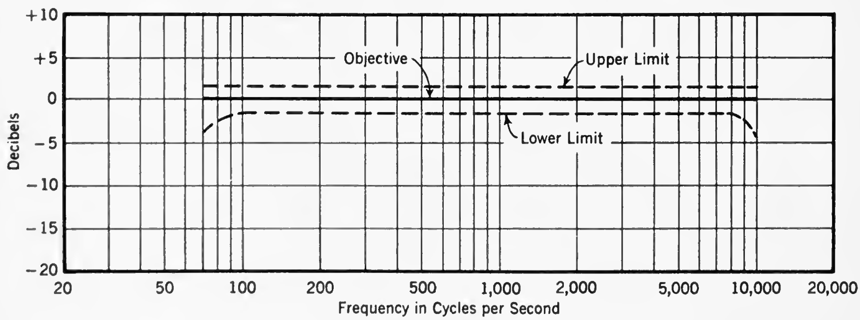

Fig. 6. Amplifier frequency response design limits.

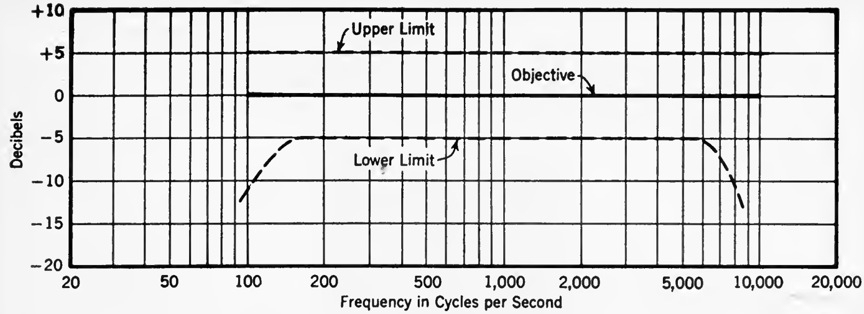

Fig. 7. Loudspeaker acoustical response frequency design limits.

identical with what is used in the review rooms in Hollywood. The VU (volume unit) meter is calibrated as to the zero-level reading by reproducing the SMPTE 400-cycle standard-level film. The dynamic-range amplifier is adjusted to indicate full scale on the volume-level indicator when using this level film. This was necessary to enable us to measure low-level dialogue sequences on the film, which would give no meter indication whatsoever if a zero-level meter setting were used.

The Motion Picture Exchange review room as shown in Fig. 8 is 60 ft long, 30 ft wide and 20 ft in height. It is made of cinder block which supplies some acoustic deadening. Therefore, our screening room is not unlike most of those in Hollywood, with the single exception that it is somewhat more reverberant. The 16mm projection equipment used in the screening room is identical in performance with that of standard review-room 35mm projection equipment.

Use of Sulfide Photoresistive Cell

One more factor of interest, to us at least, and a very important factor, was that we had pioneered, in the IC/QEB equipment, with the use of the sulfide photoresistive cell. Our reasons for using the cell were to secure a wider frequency range, higher signal-to-noise level, elimination of photocell hiss, elimination of photocell microphonics and the elimination, in the sound head itself, of high impedances which are always a source of trouble in high humidities.

In order to corroborate our thinking with regard to the use of this cell, and to check its overall performance, two projectors were used in the evaluation of film. One projector contained the conventional cesium photoelectric cell, while the second projector was equipped with a sulfide photoresistive cell. Both of these projectors were then adjusted in output level, using the Society's 400-cycle standard level film, so that they gave the same reading on the VU meter. It then became standard practice to screen all film on the two projectors in order to determine any difference in the reproduction of film from either one of the cells. We have amassed considerable data on the various film producers' products in this manner and can state that, with the exception of dye tracks, there is no difference in the performance between the sulfide cell and the cesium cell. The blue dye track develops a signal of 5 db to 10 db less than the silver track. No other significant changes in print sound quality exist. The cell comparison data could have been presented, but have not been since there was no difference in performance other than as noted.

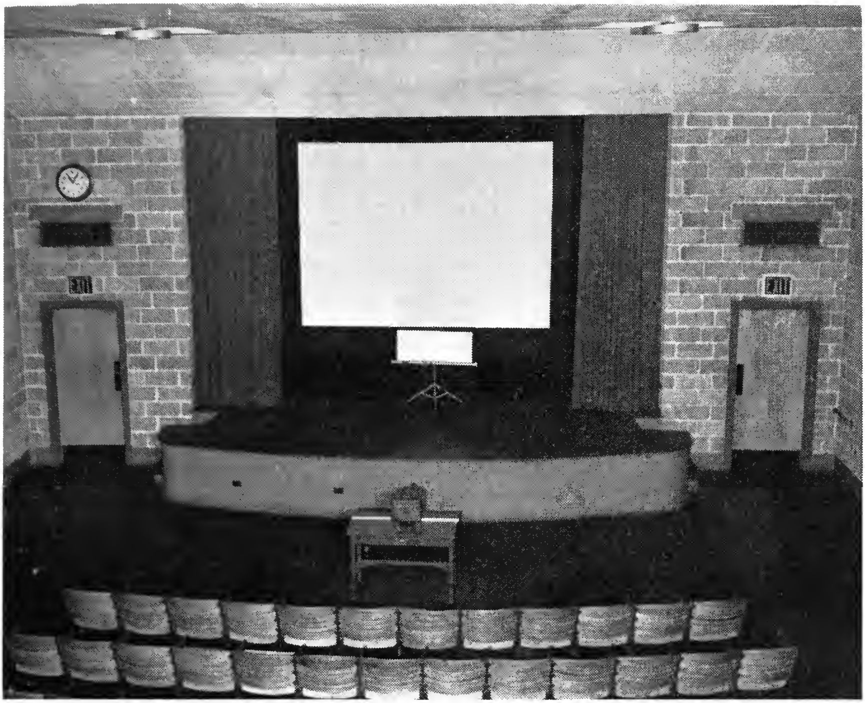

Fig. 8. Motion Picture Exchange review room.

Now, getting back to our problems with regard to high ambient noise, and the masking effect of such noise on low-level sequences, we desired to set up a test condition at the Motion Picture Exchange that would simulate quite closely conditions encountered in the field. Therefore, since we have recordings at the Material Laboratory in the New York Naval Shipyard of all types of ships' noises, used for determining the best frequency characteristics of battle-announce equipment, etc., it was convenient for us to procure records of these ships' noises and, through a reproducer system set up in the screening room, duplicate conditions aboard ship.

We also have very accurate data on the intensity of the noise at various parts of a ship, so it was not necessary for us to leave the screening room in order to determine the best dynamic range of a print. We emphasize the above because one of the most significant faults with prints, as released to us, has been the tendency to use an extremely wide dynamic range on the assumption that the film is going to be listened to in a theater, under optimum listening conditions, where such a range is practical. Now that we have established the test condition, we would like to point out that this study was made possible through cooperation and collaboration with the Society of Motion Picture and Television Engineers and more especially with its Subcommittee on 16mm Sound Reproduction.

The factor of print quality, insofar as distortion is concerned, or frequency range, having to do with the naturalness of the sound, and the overall quality

of the sound have all been carefully considered in our analysis of prints. The quality of sound, of course, is not subject to any method of measurement and, in a sense, is a matter only of the listeners' acceptance of what he considers good quality. Our discussion here, therefore, deals not with this phase of print quality, soundwise, but purely with the factor, more important to us for the moment, of the dynamic range in release prints. In securing these data we had the opportunity, as you may appreciate, of working with specimens from every major producer. The producers are not identified by name, but are marked in such a way that we can identify their respective products. In Table I are the data for both black-and-white and color, including both variable-area and variable-density tracks. The maximum peak, derived from the volume indicator, is given in terms of decibels below the selected zero level as indicated below. The average peak is also in terms of decibels. The minimum peaks, or the low-level parts, are not indicated here, as they are in many cases too low in level to show on the instrument.

From these data the reader will appreciate that low-level dialogue sequences would be completely masked by any distracting noise or poor acoustical conditions. It is our hope to have film in the future in which this will not be the case. We have, then, an analysis of thirteen producers' products with regard specifically to dynamic range. As presented in Table I, these products indicate what the current practice is with respect to the dynamic range of 16mm entertainment film release prints.

To establish a basis for comparison with the data in Table I, the measurements on the current SMPTE 16mm Sound Service Test Film Type SPSA are given in Table II. Table III is a summary average of the data contained in Table I. By way of further analysis there are shown in Table IV the most and least favorable readings taken in this survey of both types of sound tracks in black-and-white and color. It should be noted that the producer of a "best" sound track is also capable of producing a "worst" sound track.

From the preceding it can be seen that to reproduce satisfactorily all prints offered to the Navy, the equipment would have to be designed with a reserve gain of at least 25 db. That, then, means that particular color prints are 20 db below standard black-and-white prints as released for system check by the Society of Motion Picture and Television Engineers.

The preceding data on the dynamic range of current release prints are the basis for experiments conducted at the Motion Picture Exchange in determining an acceptable degree of compression of the dynamic range.

The synthetic ship's noise generator was energized in the review room to establish an 80-db acoustic noise level approximately 30 ft from the program speakers. The acoustic noise level of 80 db is not an uncommon noise level aboard Navy vessels.

Feature films were then reproduced, with the distracting noises previously described, and their intelligibility determined.

We found, by actual experience, that the degree of compression which did not completely destroy the sense of realism was limited. However, we have come to the conclusion that a real improvement in overall sound intelligibility, without destroying the artistic value of the film, or increasing the print sound distortion, could be realized by raising the low-level dialogue sequences 6 db. Peak levels as well could be raised 3 db without difficulty.

This, then, is an attainable improvement in the dynamic range of release prints.

We are presently using the industry averages shown in Table III in evaluating the acceptability of prints for Navy use. (It is our intent to eliminate from

Table I. Dynamic Ranges in Release Prints

Producer, date and total no. of releases	No. B&W V-A	Peak, db Max.	Peak, db Avg.	No. B&W V-D	Peak, db Max.	Peak, db Avg.	No. C V-A	Peak, db Max.	Peak, db Avg.	No. C V-D	Peak, db Max.	Peak, db Avg.
A, 3-15-51 – 9-11-51(21)	(5)	−4	−10	(11)	−7	−13.4	—	—	—	(5)	−9.9	−18
B, 3-19-51 – 9-14-51(35)	(27)	−6	−14	(2)	−5	−11	(6)	−9	−17	—	—	—
C, 3-15-51 – 9-10-51(29)	(8)	−7	−13.5	(9)	−9	−16	(10)	−8	−15	(2)	−5	−12
D, 5- 4-51 – 9-13-51(11)	(8)	−6	−14	(3)	−7	−12	—	—	—	—	—	—
E, 3-20-51 – 9-13-51(27)	(12)	−2.8	−9.8	—	—	—	(15)	−12	−21	—	—	—
F, 3-30-51 – 8-30-51(18)	(14)	−6	−13	—	—	—	(4)	−8.5	−15	—	—	—
G, 3-23-51 – 9- 7-51(30)	(16)	−4	−11	(6)	−10	−18	(8)	−8	−15	—	—	—
H, 3-19-51 – 9-11-51(9)	(9)	−5.7	−6.4	—	—	—	—	—	—	—	—	—
I, 3-20-51 – 9-13-51(28)	—	—	—	(12)	−6.8	−12.9	(16)	−7.8	−15	—	—	—
J, 4- 2-51 – 9-13-51(7)	—	—	—	(7)	−8.6	−18.8	—	—	—	—	—	—
K, 3-20-51 – 9-10-51(16)	(16)	−4.7	−10.9	—	—	—	—	—	—	—	—	—
L, 3-29-51 – 4-24-51(4)	(2)	−6.9	−16.5	(2)	−15.1	−20	—	—	—	—	—	—
M, 6-14-51 – 9-10-51(5)	(2)	−6.5	−13	(3)	−7	−11.5	—	—	—	—	—	—

Table I

Key: Producers identified as A – M; number of prints given in parentheses; B&W V-A, black-and-white variable area; B&W V-D, black-and-white variable-density; C V-A, color variable-area; C V-D, color variable density.

Navy distribution the worst examples given on the "extreme quality" figures [Table IV] since there is obviously no possibility of manufacturing a projector to reproduce these low-level prints satisfactorily, and if there was, the signal-to-noise level of such a print would render it valueless.)

It is significant, as pointed out at the beginning, that there are many users of 16mm copies of 35mm entertainment films. It is notable that in Class "A" releases in 35mm some 350 prints will be made for commercial exhibition. Every care and consideration is given to the making of such 35mm prints since the audience to which they are to be shown represents the major source of revenue to the industry. In order to insure and protect this source of revenue, the prints must in all respects be heralds of the art of the motion picture. Nothing is permitted which would detract from that art.

There is no disputing the soundness of the precautions taken to prevent release of inferior 35mm prints. In fact, the engineer has been successful not only in improving and enhancing the input into the sound and motion picture camera, but he has also translated the sound and image, through processing techniques, into 35mm release prints which are truly symbols of the art of the motion picture.

Why has this same effort not been made in the direction of 16mm release prints? Certainly the same factor of inviting audience appreciation is present. The Navy and the other Armed Forces do represent a large segment of the motion picture viewing population. From that standpoint alone, we are

Table II. SMPTE Test Film, Black-and-White Print.

	Max. level	Avg.
Dialogue test (sound excellent)	−6 db	−10½ db
Piano test (sound excellent)	−6	− 8
Orchestra (sound excellent)	−2	− 8
Opening music	−2	− 8

Table III. Overall Average of Data in Table I, for Total of 240 Prints and Releases Over Period From 3-15-51 to 9-14-51.

Type of track	No. of prints	Max. peak	Avg. peak
Black-and-white, variable-area	119	−6 db	−12 db
Black-and-white, variable-density	55	−8	−14
Color, variable-area	59	−9	−16
Color, variable-density	7	−7	−14

Table IV. Volume-Level Extremes.

	Best Film			Worst Film		
		Peak, db			Peak, db	
Type of track	Producer	Max.	Avg.	Producer	Max.	Avg.
Black-and-white, variable-area	E	−0	− 4	D	−14	−20
Black-and-white, variable-density	A	−3	− 6	A	−14	−26
Color, variable-area	G, I	−2	−10	G	−16	−26
Color, variable-density	C	−4	−10	A	−20	−30

sure that you will agree that the deprecation of the "Art" in the form of poor sound and picture 16mm release prints is undesirable.

This, then, is not only our problem, but more largely it is the problem of the motion picture producer and engineer in turning out a 16mm release print that can, as far as practicable, herald the art of the motion picture to the extent that the current 35mm print is symbolic of that art.

Discussion

John Hilliard: I'd like to ask Lloyd Goldsmith, Joe Aiken, Samuel Cohen, Norwood Simmons, Fred Albin, Art Blaney and Eddie Reichard, if he's here, to come up and be available for questioning in this period.

We will proceed with a direct question-and-answer period so that the Navy can have available information which they specifically came out here for.

The first question that they are interested in, perhaps, will be a brief review of optical reduction from 35 to 16, and if Sam is not here, Eddie would you come up and briefly review for us the process that you use in connection with optical reduction of 35mm prints to 16? Tell Mr. Cowett and Mr. Orr the process involved in both black-and-white and color. I see Mr. Cohen is here. Sam, we've asked that you review for us briefly the optical reduction technique that you use in your laboratory to produce the 16mm prints similar to those used by the Navy. In other words, explain what the technique is in connection with both variable-area and variable-density.

Sam Cohen: Is this with regard to sound track and picture?

Mr. Hilliard: Both, but principally in connection with sound track because they are having difficulties in evaluating problems in connection with variable-area and variable-density — something that Mr. Cowett can elaborate on as we go along.

Mr. Cohen: I may be taking a bad step here: but in every case we recommend re-recording the sound negative and not making dupe negatives from the 35 material. Dupe negatives made from the 35 material do not give nearly the quality obtained when a 32–35 track is recorded with 16mm characteristics.

Mr. Hilliard: They are unfamiliar with the technique of optical reduction from 35 to 16 and could you inform them?

Mr. Cohen: In optical reduction there are various machines that reduce the 35mm to a dupe negative 0.8 in width and 0.4 in length. To take area as one specific case, we take the 35mm fine-grain which is made to a density of 1.90 to get a slightly filled 35mm fine-grain track. This is reduced to a sound-recording stock and is exposed to reach proper density by developing in a high-contrast developer. We obtain a negative density slightly lower than an original recorded negative. That is, an original recorded RCA negative would be a density of 2.75 and a dupe negative would be 2.5 on sound-recording stock developed in high-contrast developer, optically reduced 0.4 in length, 0.8 in width, and this gives a variable-area 16mm negative from which your reprints can be made. On variable-density, this can be done either on a positive or negative stock. We have achieved better results by duping to a panchromatic stock and developing it in a negative developer of low contrast. Panchromatic stocks developed to a gamma of 0.55 will closely reproduce the original bias and unbias densities

Mr. Hilliard: In your judgment, is there any difference between the development for variable-area and variable-density that would reflect a change in quality for the 16mm work aboard ship.

Mr. Cohen: If they are not developed in the proper developers there will be a definite loss. In variable-area, for instance, many times laboratories try to make composite dupe negatives from variable-area material and naturally they're miles apart because the picture dupe should be developed to a gamma of 0.55 on a low-gradation stock, where the sound should be developed to 3.00 plus gamma on a high-contrast stock. So if you try to make a composite or a single variable-area dupe and develop it in negative-action developer, the results would be atrocious and the same goes with variable-density. If you try to put that on a high-contrast stock and develop it in a high-contrast developer, you would have bias – unbias going from 0.30 to 1.30 or thereabouts. You couldn't compensate in printing.

Mr. Hilliard: There has been indicated some difficulty with variable-density as compared to variable-area and I would like to have Mr. Cowett make a few remarks along that line to see if we can help him in that connection.

Philip Cowett: Every report that we have received from the field, from many ships out in various parts of the world, indicates that variable-density is the one source of headache and all ask, "Can all of our prints have variable-area sound tracks?"

Mr. Cohen: Are those prints you're talking about or dupe negatives? I don't understand. Do you want the release prints to be on variable-area track?

Mr. Cowett: Yes.

Mr. Cohen: I see. Well, there is a definite reason for that. We run into that a good deal with television stations. A picture recorded for 35mm, either in density or area, does not have the characteristics to give volume necessary in the 16 projector; the density track seems to suffer more; and improper laboratory control can hurt density track much faster than it can hurt area. If it is printed too heavy, volume is lost immediately; and on area, quality is lost more than volume — volume to some extent, but quality is lost much faster than volume.

Mr. Cowett: Is it then possible for the motion picture industry to produce all 16mm prints with variable-area tracks?

Mr. Cohen: No, there are some other factors that enter into it. It is really not necessary if the original material is made properly. We are doing 50% area and

50% density sound at the present time, and from a volume and quality standpoint each is equally good. The Navy should specify a sound track made for 16mm. In many cases I know that just 35mm frequency-characteristic tracks are being used for production.

Mr. Hilliard: That is the reason Mr. Cowett is here. He would like to obtain sufficient information so that he can stipulate what should be the optimum for both types of recording in connection with the 16mm prints that the Navy uses.

Mr. Cohen: Every Navy contract I've come in contact with stipulates certain fine grains and a certain number of prints. None of them that I've heard of has stipulated a sound track recorded for 16mm, which comprises the majority of the prints.

Mr. Cowett: I imagine that, since I am not a film man, Mr. Marks may later have something to say on that, but it would seem to me that since we were getting a 16mm print, the sound track should also be for a 16mm.

Mr. Cohen: But many of the people producing the pictures are in studios where there is no 16mm equipment, where 16mm is done outside and the contract doesn't often call for it, and they show the 35mm print; when they get their approval they ship the 35 to get the approval, and it's run in the 35 projection room, and it stands to reason that if they want that to be the best, they can obtain it, in order to sell more pictures, which is reasonable.

Mr. Cowett: We used to view the 35mm prints for acceptance and then wouldn't bother too much looking at the 16. But now we run off each print and each print is rejected if it's not good.

Mr. Hilliard: I'd like to ask Joe Aiken what experience he's had in connection with their work at the Navy laboratory, in connection with variable-area and variable-density. What do you think are the difficulties involved here with Mr. Cowett?

Joe Aiken: We have had very little comparative experience between 16mm variable-area and variable-density prints at the Naval Photographic Center, as our prints have all been variable-area for the past several years. However, since this question of dynamic range and overall level has been presented, I will describe our recording practices to see if there is a parallel with the problem which Mr. Cowett has brought up.

The Naval Photographic Center produces Navy training films primarily. Dr. Carpenter has discussed certain phases of them at this Convention. We produce a part of the training-film program; the majority are produced under contract by commercial studios and under Navy technical supervision. In many of them, sound effects and music are employed in much the same manner as in entertainment films. Usually training films are produced first in 35mm. Following their acceptance, those produced at the Photo Center are re-recorded to 16mm for release printing, with a frequency characteristic slightly restricted at both ends of the spectrum, and keeping the average recorded level as high as practical. When the ratios of levels of voice, music and effects are established in mixing for the 35mm sound track, we keep 16mm reproduction in mind. We therefore hold the dynamic range within closer limits, with less spread between highest and lowest levels, than is customary in 35mm entertainment films. Although extremely low voice passages are not permitted, the films are quite acceptable in their 35mm versions.

Mr. Cowett has stated elsewhere that the difficulties described in his paper have not been experienced in projecting 16mm prints of Navy training films. It is my personal opinion that those studios that wish to produce both entertainment films for 35mm theater release, and 16-mm prints for projection under less desirable conditions, could afford to consider the use of two techniques when voice, music and sound effects are mixed. One mixing technique is suitable for the 35mm theaters, and the other, for 16mm projection, which confines the dynamic range within closer limits, and where important voice passages are maintained at adequate levels.

Mr. Cohen: On that, here, we do all the re-recording right from the first trial print of the 35mm in order to avoid the expense of a complete re-recording job which would be quite an expensive operation

and the results are, the sound men think, quite satisfactory, without going to the original of a new dub job. It's considerably less.

Mr. Hilliard: Sam, would you briefly indicate your experience in connection with this color problem, that is the Navy's problem of large variations in volume with the difference in type of dye tracks.

Mr. Cohen: Every color process that's going through today requires a different track treatment. Certain dye tracks are being sulfided or subjected to various other treatments to enable them to be used with their present exciter lamps. Present systems haven't run into any difficulty except where the track hasn't had enough volume in the original recording. It does require a greater amount of volume than on a black-and-white track; and if the track has just been recorded for black-and-white, then is being used in a color process, it will not be completely satisfactory; and if different processes are used — such as for Technicolor — and the same product used on another process, the results would not be of equal quality.

Mr. Hilliard: Mr. Cowett indicated informally in a sound session yesterday that the green-dyed sound track on the lead sulfide cell gave little or no output.

Mr. Cohen: I don't think that the color, whether it's green or brown or black, has as much to do with it as the opaqueness or the transmission of the track itself.

Mr. Hilliard: Well, that is really the factor that we're involved in — the lead sulfide cell and the green color. You know the lead sulfide cell is most sensitive in the infrared region.

Mr. Cohen: In going through track problems, we use various types of track application and various processes in our laboratory. When viewing the tracks and listening to them you can have a different color, as some tracks go from the yellow to a dark brown in color and still retain the same amount of volume, if all of the image is there and if there is proper transmission density. But as for the green, we have used a track that does have a green color and in theatrical production the volume has been sufficient, but that volume was recorded there originally. By the way, the majority of the time we use a variable-area track, in which you can naturally get quite a volume if you go to 100% modulation, although I believe (in present theater practice) it runs around 40% modulation. You can increase that volume tremendously.

Mr. Hilliard: I'd like to direct a question to Dr. Frayne in connection with photocells that might be available to help reduce the variation with color. Is there any comment that you can make at this time?

John Frayne: Before I answer your question, I think I should clear up further some of what Sammy Cohen has been covering: for example, you lose sound level on a track if the photocell sees it as practically a transparency. It's not necessarily a matter of opacity; the track may be too transparent in some cases. For example, some of the dye tracks which may have a visual density of around 2.0 in the case of variable-area, to a photocell with a cesium surface they may appear to be as low as 0.2. In that case, of course, you lose all the contrast in the track and therefore lose volume. It is well known that the Bell Telephone Laboratories are actively engaged in the phototransistor development which may or may not have application to sound systems. There are none yet available commercially, but they would seem to be a very natural device for the sound picture business.

Mr. Hilliard: You had a question in connection with contracts?

Mr. Marks: Mr. Cohen, you mention that you are willing to supply something so long as the Navy would tell you what to supply, that since the Navy contracts didn't mention anything about 16mm print specifications, you therefore had free choice in supplying the type of prints that you did supply.

Mr. Cohen: No, there's one error. I work for a laboratory, not for a producing company, and it's the producing company that has the contract; it's the producing company that delivers to the laboratory. We are not in the sound recording business so we process whichever films the producer delivers to us. We don't tell the producer what he is to produce.

Mr. Marks: I'm not taking issue with you, but you implied that you had Navy

contracts. You had producers' contracts.

Mr. Cohen: No, I don't have Navy contracts. I said that we do work for people who have Navy contracts and they bring in certain materials and I'm telling you from practical experience just what material comes in. I am in a position to see what comes into the laboratory, probably in a very good position to tell what type of material is going out, but it is the Navy's responsibility directly to write the contracts.

Mr. Marks: You deal as a subcontractor with the Navy, you don't have anything to do with the Navy contract itself.

Mr. Cohen: No, none whatever.

Mr. Marks: So, therefore, you couldn't say that we do not specify any particular treatment in the contract.

Mr. Cohen: Well, we have to deliver all the material to the Navy. If the contract calls for a fine grain and two 35mm prints and five reduction prints, as a number of them are coming through, that material goes. We would not be making the 16mm prints from a 35mm original negative if there was a 16mm negative recorded.

Mr. Marks: Well, I agree in that respect. But the matter of fact is that the Navy does not specify the type of 16mm release prints or sound track for a very tangible reason, for the same reason that this study was made — because there was no experience with it until very recently. Now we intend to apply the results of this study.

Mr. Cohen: That is what I'm trying to bring out here. I'm not finding fault with the Navy. I'm trying to help the Navy. I'm telling you what should be put into the contract in order to get a result, so that on board ship they would have prints with volume.

Mr. Marks: We are not prepared to insert anything into the contracts based on this study alone. That is why we are inviting the study of the Society of Motion Picture and Television Engineers in order to help us arrive at a specification which is practicable, both from our standpoint and from the capacity of the industry to produce. We don't want anything unreasonable from the companies. However, from a contractual standpoint, every time an order is placed, regardless of whether the type of film is specified, there is an implied liability upon the part of the producers to supply a product which is fit for the use intended. We maintain that at the present time nothing is being supplied, except in rare cases, which is ultimately fit for the use intended, soundwise, when compared with the Society's 400-cycle test film. Along with that, every producer has been charged with the knowledge that we are using this JAN 16mm projector.

Mr. Cohen: If all this were true, there would be no problem.

Mr. Marks: Well, I agree and that's why we're bringing it to the attention of you people, in order to help us to help ourselves. And I think, personally, it should be a matter of pride with the entire industry to attempt to produce a print which will have the same artistic impact that it has on the general public in the form of a 35mm print.

Loren L. Ryder: In the discussion that is taking place a quality comparison has been made between reproduction of area and density 16mm sound films. During these discussions no mention has been made of supersonic direct-positive prints of the density type. Direct-positive supersonic density prints on 16mm film when reproduced on proper equipment are comparable to 35mm optical prints. If a decision is made, it should be made after a study of what may be done and not based solely on past practices.

Lloyd Goldsmith: I think Mr. Cowett's paper as read today is a most timely one. As I see it, speaking from the sound-quality standpoint, the basic problem, as also stated by Mr. Cohen, is to get a rerecorded release 16mm negative. That is the first step. In the process of making that negative from previously recorded 35mm materials, the volume range must be restricted over that normally employed in 35mm recording. That is the second step, and it was very well brought out in Mr. Cowett's paper. The third step, if necessary, is to make a correction in the frequency response over that originally employed in the 35mm material. All of this is not new. It has been known

certainly since the experience we had in the last war in securing from the motion picture industry improved 16mm prints for use by the armed forces. Speaking for Warner Brothers, at least, in 1943 we were convinced that a separate release negative for 16mm was desirable and we have been making such a negative from that time.

I might mention that in making the 16mm release negative from original 35mm material, in re-recording, we do not, at Warners, change the frequency response very much. However, that is largely due to the fact that the 35mm material released for showing in theaters has a frequency range, speaking now for music, with a low end around 60 cycles, no intentional cutoff, and a high end around 6000 cycles, with an intentional sharp cutoff filter of 6700 cycles. In the case of dialogue the original material is re-recorded with the same upper-end limitation, flat to 6000, but the low end is cut off as sharply as possible at 100 cycles. In re-recording this material from 35 to 16, to make a new release negative for 16, we make no change in the frequency response. This we feel is predicated on good release printers which give good contact and will faithfully reproduce the high frequencies, whatever there are, to 6000 cycles.

The one thing we do, however, in preparing this release negative, is to restrict the volume range. We intentionally pull up the low-level dialogue passages from 4 to 6 db. As indicated in Mr. Cowett's paper, it would appear that the desirable added amount of compression would be something in that range. I might add that our original material is fairly well compressed in the 35, so we feel that an additional 4- to 6-db pull-up for 16 release is satisfactory. To help the re-recording mixers accomplish this, we force them to re-record with the gain in the mixer monitor's horn circuit reduced from 4 to 6 db. Therefore, he has to pull up the low-level dialogue from 4 to 6 db for a corresponding intelligibility which he has been used to. The high-level passages, particularly the main and end titles, in music, that are normally 100% modulated, he still holds to 100% modulation by means of peak-reading volume indicators, as it is recognized that there must be no intentional overloads in the 16mm release material, unless it be of certain sound effects which can stand such overloads without apparent distortion.

I would like to stress again those three steps: the special re-recorded release negative, compression of volume range, and restriction of frequency characteristic if necessary. That is the secret of good 16mm release sound quality from 35mm original material.

Mr. Cowett: I should like to thank the members of the motion picture industry who appeared here on this panel and hope that some day the entire industry may follow the process outlined by Mr. Goldsmith which appears to be a workable and a desirable plan.

High-Speed Motion Picture Cameras From France

By PAUL M. GUNZBOURG

Two high-speed motion picture cameras developed by the French firm of Merlin-Gerin-Debuit are briefly described. The first operates at a speed of 3000 frame/sec, using 100-ft rolls of 16mm film; the second, using standard 35mm film, can be operated up to a speed of 100,000 frame/second. Both cameras employ a rotating lens drum. In the slower camera ordinary oscillographic film unwinds continuously by conventional means. The second camera uses the device of a film strip which is attached to the interior of the lens drum rotating with it.

3000 Frame/Sec Camera

The optical principle of the camera, shown in Fig. 1, is based on the juxtaposition of a stationary objective and a series of mobile objectives passing rapidly before it. For the mobile objectives-compensators, commercial lenses with ±1% tolerances are used.

A primary objective with a focal length of 140 mm, housed in a focusing mount, is capable of focusing at distances ranging from 4 ft to infinity. For distances from 2.5 in. to 4 ft, other objectives of 50-mm (2-in.), 80-mm (3.5-in.), 100-mm (4-in.) and 120-mm (5-in.) focal length can be substituted in similar mounts.

Optical compensation is provided by a rotating drum with 80 small objectives set at equal distances around its periphery. These are three-element anastigmats with a focal length of 20 mm at an aperture of $f/3.5$. Figure 2 shows the optical drum.

The film is driven by a double row of sprocket teeth in the lens drum and passes in the conventional way from the supply to the take-up spools. The drum is made in one piece and, in rotation, controls the movement of both film and lenses. This principle provides for synchronization of both film and images without mechanical means. Undue tension of the film is avoided by having 6 to 8 teeth of the lens drum in mesh, resulting in movement of the film without tear or breakage. Power is supplied by a universal a-c and d-c 110-v or 220-v motor of high-starting torque, developing about 20 hp at starting.

A synchronizing device, operated by an adjustable electrical contact, per-

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Presented on April 6, 1949, at the Society's Convention at New York, N.Y., by Paul M. Gunzbourg, Mac Donald International, Inc., 115 Broadway, New York 6, N.Y.

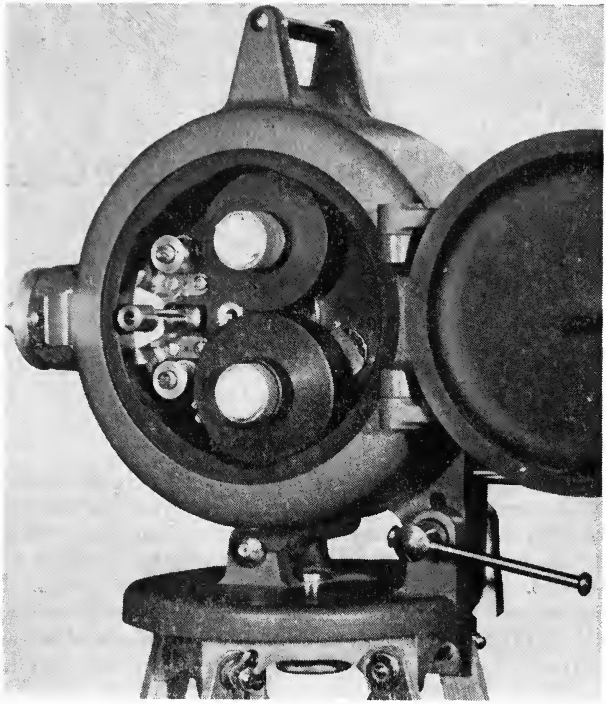

Fig. 1. Interior view of 3000 frame/sec camera.

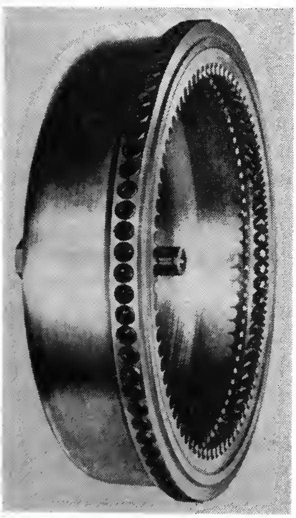

Fig. 2. Optical drum of 3000 frame/sec camera.

mits the camera circuit to be closed or opened in accordance with the length of film desired to be exposed. Since the current draw is about 0.5 amp, a contactor relay is necessary for the starting and stopping of the motor. This device may be adjusted according to the synchronization requirements of the phenomenon being photographed or to the length of film in the camera.

A set of changeable slits of various widths is provided with the camera. These slits, fitted between the fixed objective and the mobile objectives on the lens drum, permit the decrease of the exposure time per frame at a given frame frequency by a ratio of 1:4. A centrifugal brake with which the motor spindle is equipped permits the adjustment of the speed within the range of $\pm 10\%$. This adjustment can be ap-

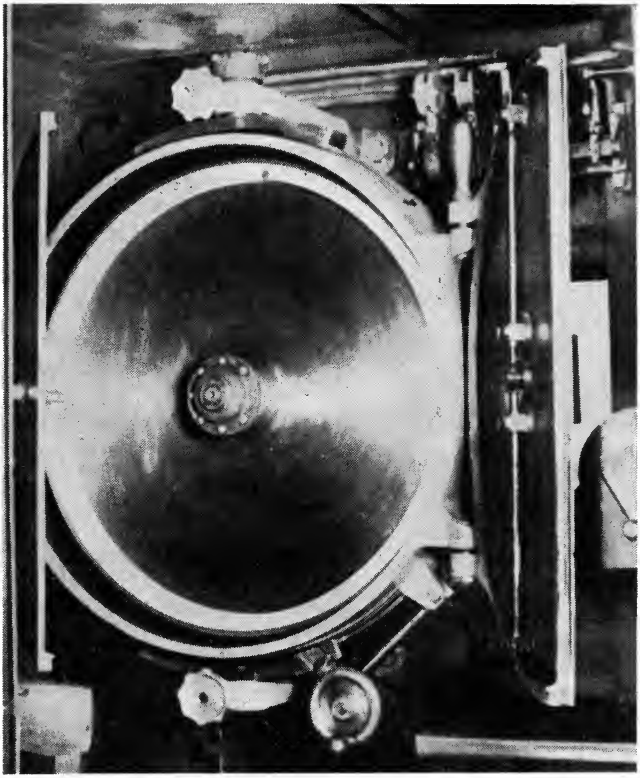

Fig. 3. Interior view of 100,000 frame/sec camera.

plied from the moment when 10–12 m (33–40 ft) of film have been unwound.

Accessories of the camera consist of a reinforced braced tripod and a focusing microscope to be attached to the view-finder. The camera itself weighs about $16\frac{1}{2}$ lb without motor and accessories, and can be easily handled.

100,000 Frame/Sec Camera

The same principle of optical compensation is used in the 100,000 frame/sec as in the 3000 frame/sec camera. The basic difference in the design of the two cameras lies in the device adopted in the faster camera to allow for movement of the film at the far higher rate of speed required.

Since no film could withstand being driven at such high speed by any of the conventional film drives, the film in this case is applied directly against the inner surface of a rotating drum, 0.605 m in diameter, and can thus be rotated with it at the required speed of 250 m/sec (820 ft/sec) without damage. The length of film that can be used is, of course, determined by the circumference of the inner surface of the drum wall, which measures 1.90 m (74.8 in.). One revolution of the drum results in 750 pictures, representing a 50-sec projection at normal speed when the frames are placed in sequence. For example, with the drum rotating at 6000 rpm (film velocity 190 m/sec) the frame frequency resulting is 75,000/sec for a total duration of 0.01 sec.

Fig. 4. Billiard ball falling into glass of water. Speed: 2500 frame/sec.

The optical drum carries on its periphery 750 fixed compensator objectives, arranged in three rows, of 250 lenses each, parallel to the drum axis. Each row is staggered one-third of the level of the adjacent row below it. One lens from each row is uncovered in turn, a slit being used to limit the angle and the exposure duration per frame. The objectives are three-element anastigmats with 20-mm focal length and $f/3.5$ aperture. The film is held taut on the inner surface of the drum against the objectives, by a flexible bronze strip applied on the reverse side of the film acting as a rear pressure plate. An interior view of this camera is shown in Fig. 3.

As the drum rotates, the compensator objectives pass before a fixed objective having a diameter of 70 mm and a focal length of 350 mm. The fixed objective is fitted with an automatic magnetic capping shutter, synchronized with the motion of the drum, and operating when the drum reaches the desired speed of rotation. The shutter closes after one complete revolution of the drum. The length of film in the camera is thus fully utilized.

The sequential images produced in this camera are presented as three circular images, each 6.5 mm in diameter, lying obliquely across the film, with frame 1 produced by a lens in row 1, frame 2, by the next lens to be uncovered in row 2, and the third, by the corresponding lens in row 3. For projection purposes, the images are optically printed, approximately three times enlarged, onto standard 35mm film, as shown in Figs. 4 to 7. Lighting sources used in the examples shown here were either flashes of $3\frac{1}{2}$ oz of magnesium set off behind ground glass, or two projection-light sources with parabolic reflectors fitted with 2-kw bulbs, also behind ground glass.

Power is provided by a compound 150-v, d-c motor requiring about 0.5 hp. Viewing is through a shutter-equipped window. Other features inside the housing include contactor and push-button devices for starting and stopping the driving motor, and for unwinding and developing the film automatically. The camera weighs approximately one ton.

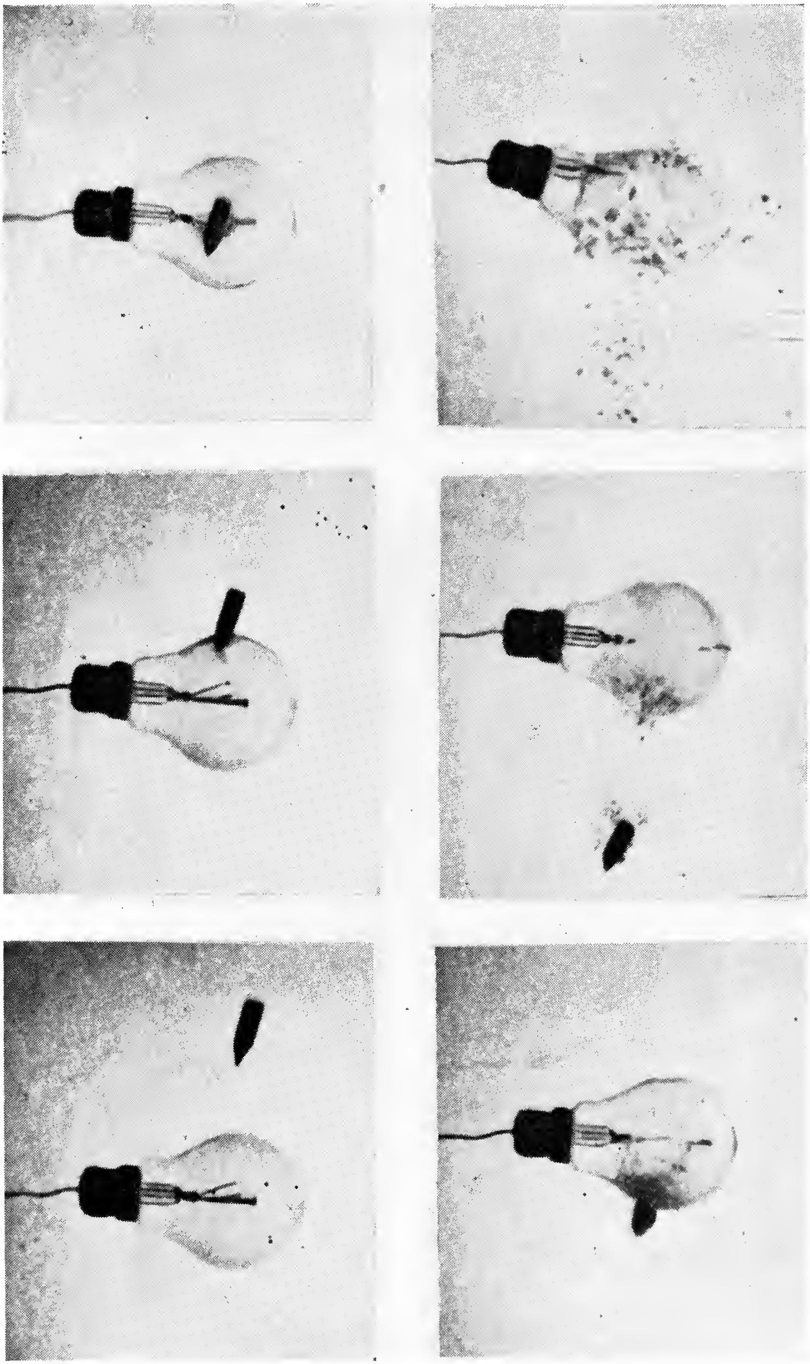

Fig. 5. Perforation of electric light bulb by bullet. Speed: 75,000 frame/sec.

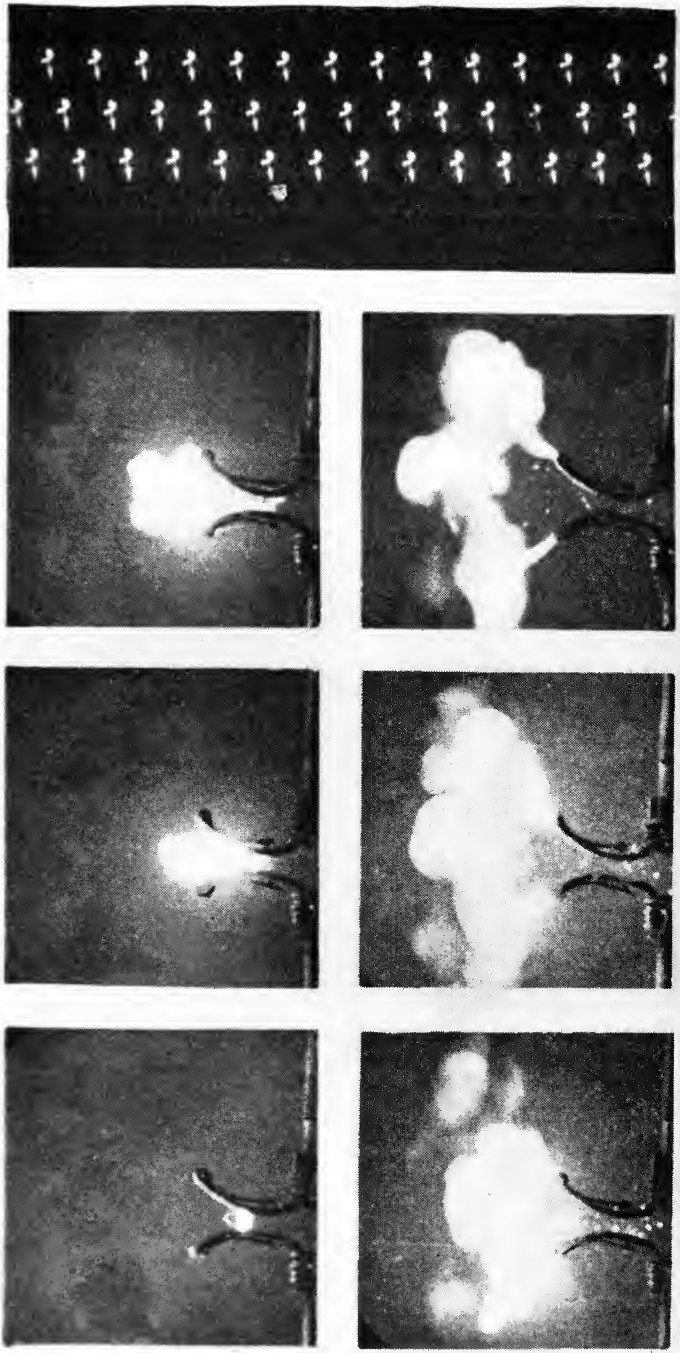

Fig. 6. Electric arc (d-c) between two electrodes. Right: exposed film, reduced one-third. Speed: 75000 frame/sec.

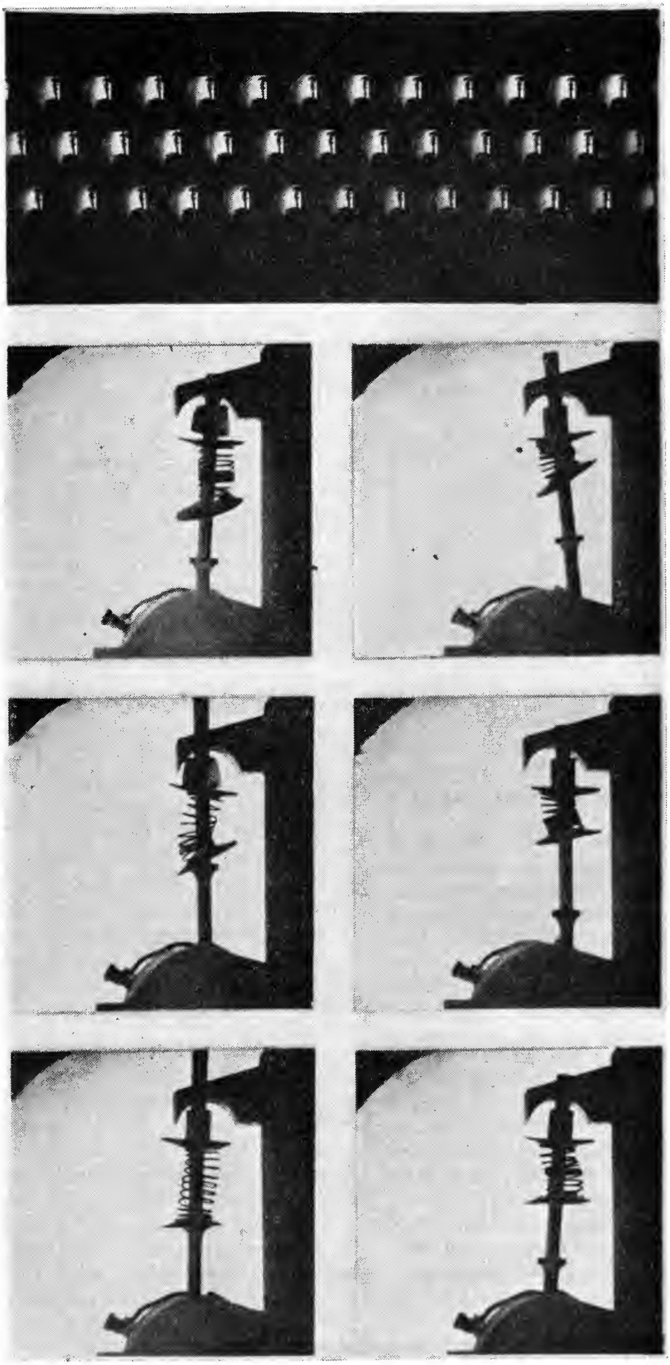

Fig. 7. Spring strained to distortion. Right: exposed film slightly reduced.
Speed: 75,000 frame/sec.

Biographical Note

A. C. Downes

"Arthur C. Downes, Chairman, Board of Editors" has been appearing month after month for 11 years in this *Journal:* no more propitious words could appear on the *Journal's* masthead.

We do not apologize for thus introducing a man who has retired from a long and successful career as chemist, engineer and research leader. Those who have known him over some years will agree that in speaking of him it is in order to treat the immediate immediately — while not slighting what is more distant.

The quality of the recent Volumes of this *Journal* has been the direct result of a great deal of constant attention by Mr. Downes, who reviews every paper, assesses the evaluations made by those he chooses from the Board of Editors to study each paper, and prepares the verdicts and often extensive advice for authors. This service is not a casual part-time hobby. It is a job of carefully winnowing each year at least a couple of solid bushels of papers — to find some completely acceptable for publication, some satisfactory in part and others which must be rejected. The Chairman of the Society's Board of Editors is responsible for assessing them all.

(We should note here that these extensive activities of the Chairman of the Board of Editors for today's *Journal* are made possible by efficient secretarial service given by the staff of National Carbon.)

Arthur Caldwell Downes was born in Ipswich, Mass., in 1882. (This and a few other milestones are here recorded, chiefly from *American Men of Science*, 8th ed., 1949): B.S. from Massachusetts Institute of Technology in 1904; chemist at Hartford Laboratory Co., 1904–05; National Carbon Co., Cleveland and Fostoria, Ohio, 1905–17; Assistant Superintendent of National Carbon's Fostoria Works in 1918–21, Cleveland Works in 1921–22 and Niagara Works in 1922; directing work on illuminating carbons, electrical brushes and new carbon products, he was head of the Works Laboratories in Cleveland in 1922–25 and the Development and Research Laboratory from 1925 until his retirement in 1947.

He has been a member of this Society since 1927 and a Fellow since 1934. He served as Editorial Vice-President in years very critical for the *Journal* and for Conventions and Papers Programs — 1941–46. During these six years he also served as Chairman of the Board of Editors.

In 1947 Mr. Downes was made a Fellow of the Illuminating Engineering Society which then cited his 40 years as an illuminating engineer, his IES committee work and his many contributions to *IES Transactions*, principally with reference to spectral characteristics of sunshine and its substitutes. In 1928 he received the award of the Academy of Motion Picture Arts and Sciences for his illumination research. He is also a member of the American Chemical Society and the American Institute of Chemical Engineers.

A. C. Downes did a good deal of work in Hollywood beginning in 1935 when high-level illumination was being developed by Mole-Richardson Co. for the studios to use with the new Technicolor process. It is, some think, farther than

the map shows from Arthur Downes' birthplace in Ipswich, Mass., to Hollywood. In between, it is true, is Cleveland, where one of his associates reports, "He has always been known simply as 'A. C.' and his long-time and expert knowledge of carbon formation procedures and of the light-emitting properties of illuminating carbons has been continually respected and put to good use by his co-workers."

Though long known as A. C., he is also known as one who uses direct current methods to get things done — forthrightly, efficiently and with understanding. And this is how he got on in Hollywood, according to a note from Elmer Richardson:

"Here in Hollywood we probably go overboard with our informality. No one works in the Hollywood technical group long before he is better known by his first name than his surname. Right from the start among ourselves, we always referred to A. C. Downes as Arthur, but at first we did not want to offend him so we all stuck with 'Mr.' One day when we were all together, some one said: 'Let's have some fun,' so Pete (Peter Mole) was nominated to start addressing our good friend, Mr. Downes, as 'Arthur'; and so Pete, in his quiet way, with a twinkle in his eye 'broke the ice.' I think Arthur was a bit flabbergasted at first but after he got accustomed to it, I think he was as happy as we were to drop the 'Mr.'

"Arthur Downes to me is a friend, a man with that combination of intelligence, experience and knowledge that is best defined as wisdom, and with human qualities that make cooperation with him a delight to all concerned."

71st Semiannual Convention

The Advance Notice listing the sessions and abbreviated titles of papers went to members in the Western Hemisphere on March 10. That was the mailer which includes the tear-off postal card for conveniently arranging hotel accommodations at The Drake in Chicago during the Convention. If you have mislaid yours, please refer to p. 173 of the February *Journal*, which has the information you need.

Here is the schedule of 11 sessions in which Program Chairman George Colburn had some 52 papers arranged at press time:

April 21–25

Monday afternoon and evening
Television

Tuesday morning
Screens and control of brightness

Tuesday afternoon
Armed Forces production

Tuesday evening
Magnetic projection; Film inspecting; Future use of educational film

Wednesday morning and afternoon
High-speed photography

Thursday morning
Open

Thursday afternoon
Color; Laboratory

Thursday evening
General Session

Friday morning
Sound and editing

Friday afternoon
New equipments

There will be demonstrations of equipment, guaranteeing lively and concrete interest, and we can be sure that Bill Kunzmann's arrangements are auspicious for the Get-Together Luncheon, the Cocktail Hour and the 71st Semiannual Banquet and Dance.

Bill and all the Chicago folks responsible for making the many Convention wheels turn are meeting in Chicago on March 13 for a planning session for which all the signs are good. The roster of chairmen, which was completed at an early date, was published in the February *Journal.*

Book Reviews

The Television Program
Its Writing, Direction and Production
By Edward Stasheff and Rudy Bretz. Published (1951) by A. A. Wyn, 23 W. 47 St., New York 19. 355 pp. incl. glossary and index. Numerous illus. and examples. 6 × 9 in. Price $4.95.

The Television Program is probably the most complete study of television production practices and techniques to date. It should be recommended for a thorough reading by everyone in television and the connected industries, either as a means of reviewing and comparing techniques or as a method of exploring the nature of the new medium.

The authors bring a solid background of actual experience to their work. Edward Stasheff has been in the industry since 1945, serving as educational consultant to CBS, assistant program manager to Station WPIX and as a teacher at Columbia and Michigan Universities. The television record of Rudy Bretz is even longer, including work as a cameraman, as a teacher and as program manager of WPIX.

For easy assimilation, the book is divided into four parts: (1) the nature of the television program, (2) the writing of the program, (3) the writing of the fully scripted show, and (4) the producing and directing of television.

Part One analyzes the television program and points up the differences between it and other media. Television production units are described, with the authors realistically bringing out the limitations imposed by budgets, time and space. Types of television shows are listed and described by formats and finally the reader is given a cursory run-down of the basic shots and visual transitions currently used in television.

Two sections are devoted to writing the television show. Of particular interest to engineers would be sections 12 and 14, respectively, "Technicalities of Writing for the TV Camera" and "Transitional Devices."

Part Four, "Producing and Directing the Television Program," has the ring of authenticity that comes from personal experience. Not only are the functions of the producer-director set forth, but the spirit motivating the production art is nicely translated into words. Television aspirants looking for a "bible" of the television production art, complete to the current moment of publication, can find it here in Part Four.

It should be especially noted that each section of the book is illustrated with charts, diagrams and reproduced "air" scripts, the latter embellished with photographs of the action as it would be seen by the television camera.

Next to actual experience and observation, research is an effective way to learn television production. For those interested in using this method, *The Television Program* will be found invaluable.—*Dik Darley*, Director, American Broadcasting Company, ABC Television Center, Hollywood 27, Calif.

Motion Pictures, 1912–1939

A catalog compiled by the Library of Congress. Published (1952) by the Copyright Office, Library of Congress, Washington 25, D.C. 1256 pp. Bound in buckram. Price $18.00.

The press release of the Library of Congress describes this as a monumental catalog that lists more than 50,000 motion pictures registered in the Copyright Office from 1912 through 1939 and notes that the catalog contains much information that has hitherto been available only after prolonged research in the files of the Copyright Office. The release also contains the information which follows.

As time passes and old producing companies and their films are forgotten, this volume will become increasingly valuable as a reference book on films and film history. The information given about each film includes, insofar as possible, the title, date, producing company, sponsor, information about the published work on which the film was based, physical description, credits, claimant and date of copyright, and the author of the film story. The material for the entries, which are listed alphabetically, was obtained mainly from the record books of the Copyright Office, the original applications for the

registration of the copyright claims, and descriptive material that was supplied at the time the films were registered.

The cumulative catalog has a 268-page index, which lists the individuals and organizations associated with each motion picture, and a "Series List," which provides the name of the copyright claimant and the title and date for each motion picture of a series. Any particular film may be located in a variety of ways—by title, producing company, copyright claimant, alternate title, name of the work on which the film was based, series title, author of the film story, sponsor, and releasing or distributing agents.

Motion Pictures, 1912–1939 is the first publication in the cumulative series of the *Catalog of Copyright Entries.* Work has started on a supplementary volume that will cover motion pictures copyrighted in the years 1940 to 1949. These two cumulative volumes and the subsequent semiannual issues of *Motion Pictures and Filmstrips* in the regular series of the *Catalog of Copyright Entries* will constitute a comprehensive bibliography of United States motion pictures from 1912 to date.

Current Literature

The Editors present for convenient reference a list of articles dealing with subjects cognate to motion picture engineering published in a number of selected journals. Photostatic or microfilm copies of articles in magazines that are available may be obtained from The Library of Congress, Washington, D.C., or from the New York Public Library, New York, N.Y., at prevailing rates.

American Cinematographer

vol. 32, Nov. 1951

Set Lighting by Remote Control (p. 444) *A. Rowan*

Reflected Light for Color Photography (p. 446) *L. Allen*

Dual-Purpose Projector (p. 450) *R. Lawton*

Planning and Estimating TV Spot Announcement Films (p. 454) *J. H. Battison*

vol. 32, Dec. 1951

Motion Pictures on Tape (p. 500) *F. Foster*

Trick Effects in TV Commercial Films (p. 502) *J. H. Battison*

Audio Engineering

vol. 36, Jan. 1952

The Two Types of Theatre Video (p. 16) *J. W. Sims*

Bild und Ton

vol. 4, Oct. 1951

Zur Messung Fotografischer Zentralverschlüsse (p. 300) *H. Pech*

Die Bewegungskamera und ihre Anwendung (p. 307) *W. Rieger*

Abmessungen für 16-mm-Transportrollen und die 16-mm-Schaltrolle (p. 318) *A. Heine and L. Busch*

British Kinematography

vol. 19, Oct. 1951

The Gevacolor Processes (p. 100) *H. Verkinderen*

The Economics of Film Production (p. 110) *C. Vinten*

Standardization of Projection Lamps (p. 117) *M. Furness*

vol. 19, Nov. 1951

A Photographic Technique for Producing High Quality 16mm Prints (p. 132) *A. Tutchings*

A Method of Making Travelling Mattes Using a Single-Film Camera (p. 139) *G. I. P. Levenson and N. Wells*

A Non-Reflecting Room and Its Uses for Acoustical Measurement (p. 148) *F. H. Brittain*

Electronic Engineering

vol. 23, Dec. 1951

Picture Storage Tubes (p. 472) *R. E. B. Hickman*

Electronics

vol. 24, Dec. 1951

Improving a Film-Camera Chain (p. 103) *C. J. Auditore*

vol. 25, Jan. 1952

Specifications for Color TV Field Tests (p. 126)

Ideal Kinema

vol. 17, Dec. 6, 1951

Third Dimension Demonstration by Means of Sextuple Screen (p. 15 and p. 19)

International Projectionist

vol. 26, Dec. 1951

Movie Studio Carbon Arc Lighting (p. 11) *H. B. Sellwood*

The GPL Simplex Direct-Projection Theatre TV System (p. 22) *F. N. Gillette*

vol. 27, Jan. 1952

DuPont's New "Thin" Film Related to Dacron Fiber (p. 10)

Kollmorgen's New Optics Plant (p. 15)

To Mask or Unmask (p. 16)

Kino-Technik

no. 11, Nov. 1951

Der plastische Film vermag dem Kino neue Impulse zu geben (p. 224)

Störungen bei der Vorführung von Tonfilmen (p. 228)

no. 1, Jan. 1952

Siemens-Projektor 2000 — Ein neues Gerät für die Schmalfilm-Projektion (p. 10) *L. Busch*

Neue Aufnahmetechnik durch das "Travelling Matte"—Verfahren (p. 12)

Störungen bei der Vorführung von Tonfilmen, Pt. 2, (p. 16) *K. Braune and H. Tümmel*

Motion Picture Herald

vol. 186, Jan. 5, 1952 (Better Theaters Section)

How Theatres Can Be Revised for "Full Vision" (p. 8) *B. Schlanger and W. A. Hoffberg*

vol. 186, Feb. 9, 1952

Operation and Maintenance of Theatre TV Equipment, Pt. 6, 35mm Intermediate System (p. 40) *A. Nadell*

Photo-Technik und-Wirtschaft

vol. 2, Nov. 1951

Über die Farbentwicklung im Agfacolor-Negativ/Politiv-Verfahren Reckziegel (p. 446)

RCA Review

vol. 12, Dec. 1951

Fundamental Processes in Charge-Controlled Storage Tubes (p. 702) *B. Kazan and M. Knoll*

Radio and Television News

vol. 47, Jan. 1952

Practical Sound Engineering, Pt. II (p. 66) *H. Tremaine*
(The concluding article of this series detailing how a complete distribution system achieves flexibility by means of patch bays)

Tele-Tech

vol. 10, Nov. 1951

Analysis of Latest Lawrence Color-Tv Tube (p. 38) *J. H. Battison*

Image Iconoscope for Improved TV Film Scanning (p. 44) *R. Theile*

Combined Special Effects Amplifier for Television (p. 50) *W. L. Hurford*

Tele-Vision Engineering

vol. 3, Jan. 1952

Video Studio Techniques (p. 8) *C. D. Parmelee*

New Members

The following members have been added to the Society's rolls since those last published. The designations of grades are the same as those used in the 1950 Membership Directory,

Honorary **(H)** Fellow **(F)** Active **(M)** Associate **(A)** Student **(S)**

Armistead, Mark, President, Mark Armistead, Inc. **Mail:** 1041 N. Formosa Ave., Hollywood 46, Calif. **(M)**

Butler, John W., Executive, Signal Corps Photographic Center. **Mail:** 11 W. Eighth St., New York 11, N.Y. **(M)**

Conway, David L., Director, Photographic and Special Events, WHEN, Meredith-Syracuse Television Co. **Mail:** Maple Hill Farm, R.D. #2, West Monroe, N.Y. **(M)**

De Titta, Arthur A., Pacific Coast Supervisor, Movietonews, 1417 N. Western Ave., Hollywood 27, Calif. **(M)**

Fox, George S., Producer, Designer, Cameraman, George Fox Corp. **Mail:** 6626 Romaine St., Hollywood 38, Calif. **(M)**

Fritzen, John, Technical Services, Cinecolor Corp. **Mail:** 11583 Huston St., North Hollywood, Calif. **(M)**

Gamon, George A., Motion Picture Engineer, Sound Service Co., Pty., Ltd. **Mail:** 6 Alameda St., Parkdale, Melbourne, Australia. **(A)**

Goldberg, Ernest W., President, Golde Manufacturing Co. **Mail:** 1140 Michigan St., Wilmette, Ill. **(M)**

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CHANGES IN GRADE

Bashner, Melvin C., **(S)** to **(A)**
Current, Ira B., **(A)** to **(M)**
Daniel, George **(A)** to **(M)**
Dieter, Henry, **(A)** to **(M)**
Hirschfeld, Gerald J., **(A)** to **(M)**
Jones, Ronald W., **(A)** to **(M)**
LaRue, Mervin W., Sr., **(A)** to **(M)**
Macbeth, Norman, **(A)** to **(M)**
Ochse, Brand D., **(A)** to **(M)**
Pessis, Georges, **(S)** to **(A)**
Rocklin, Ralph J., **(A)** to **(M)**
Schroeder, Walter A., **(A)** to **(M)**
Sherry, Frank E., Jr., **(A)** to **(M)**
Spottiswoode, Raymond J., **(A)** to **(M)**
Spring, Donald N., **(A)** to **(M)**
Streech, Wilbur J., **(A)** to **(M)**
Trentino, Victor, **(A)** to **(M)**
Youngs, William E., **(A)** to **(M)**
Von Vollenhoven, Leopold, **(A)** to **(M)**
Ward, Alvis A., **(A)** to **(M)**
Whitman, Vernon E., **(A)** to **(M)**
Wight, Ralph, **(A)** to **(M)**
William, Eric, **(A)** to **(M)**
Winn, Curtis B., **(A)** to **(M)**
Wolff, Joe M., **(A)** to **(M)**
Wutke, Louis, M., **(A)** to **(M)**

Chemical Corner

Edited by Irving M. Ewig for the Society's Laboratory Practice Committee. Suggestions should be sent to Society headquarters marked for the attention of Mr. Ewig. Neither the Society nor the Editor assumes any responsibility for the validity of the statements contained in this column. They are intended as suggestions for further investigation by interested persons.

Chemical Treatment Produces an Oil-Retaining Rust-Resistant Surface The Octagon Process, Inc., 15 Bank St., Staten Island, N.Y., markets a chemical preparation "Rustshield," which is a phosphatizing compound that imparts to a steel or iron surface a rust-resistant, highly absorbent quality thereby greatly increasing its oil-retention properties. The surface needs less lubrication and remains rust-free longer.

Increasing Emulsion Speed In an article by L. Jacobs, Jr., in *U.S. Camera, 14:* 41–3, March 1951, a new chemical called "Hydram" is described as increasing negative emulsion speed as much as ten times. Hydram is intended for use with conventional developers. The effect of this chemical is not to increase the threshold speed values but to increase the contrast in the toe part of the H&D curve. Hydram is not recommended when the developer contains sodium bisulfite, potassium metabisulfite, tartaric or citric acid.

Add More Life to Your Hypo *The British Journal of Photography, 98:* 191–92, April 1951, contains an article which has various suggestions for increasing fixer longevity: (1) use of an acid short stop; (2) use of a two-bath fixer arrangement; (3) removal of silver by some suitable means and replenishing the various chemicals which have been depleted; and (4) the addition of ammonium sulfate to the fixer. Ammonium sulfate imparts to a fixer increased fixing speed and longer life. Various formulas are also discussed.

New Plastic Sheeting A transparent plastic sheeting manufactured by The Alsynite Co. of America, 4670 DeSoto St., San Diego, Calif., may have applications in the laboratory or on the lot. This plastic is shatterproof, eliminates glare by light diffusion, is fire resistant, reduces heat transmission, has a high impact and load strength, is light in weight and is easy to install. It comes in flat panels and various colors. The sheet may be handled just like wood with a saw, nails or drill. Alsynite says that it is an improved substitute for glass.

Dispensing of Liquid From Carboys and Demijohns Greatly Simplified L. B. Russell Chemicals, Inc., 60 Orange St., Bloomfield, N.J., sell a small inexpensive ($15.50) hand-operated dispenser which fits into the mouth of carboys and demijohns of any type. Heavy carboys do not have to be rocked or tilted. The mere pressing of the bulb of the gadget dispenses the liquid from the carboy and the hazard and odor of splashing liquids are avoided. This device is made of acid-resistant plastic and fits all the way down to the bottom of the container so that all the liquid may be drawn off.

Liquid Stainless Steel The Lockrey-Frater Corp., 38–13 Tenth St., Long Island City, N.Y., may have the inexpensive answer to the laboratory's problem of protecting and decorating equipment with their "Liquid Stainless Steel." This is a paint-like material which is a suspension of finely divided actual stainless steel combined with a vinyl plastic. The liquid when applied will dry fairly rapidly and leave a coat of stainless steel on wood, metals, composition board, concrete, brick, etc.

It gives the appearance and much of the permanence of the metal itself. The coating offers the impermeability to moisture that 302 stainless steel does by an overlapping and interlocking of the flakes as they dry. Liquid Stainless Steel may be applied by spray, brush, or dip and gives a permanent coating in the bluish-gray, non-shining cast of stainless steel.

How to Get Better Film Washing BFI #20, a proprietary formula of The Brown Forman Industries, 1908 Howard St., Louisville, Ky., is claimed to increase washing efficiency and to reduce to one-twentieth the amount of hypo remaining in the film which would be there if washed with water. One gallon of BFI #20 will treat 36,000 ft of 35mm film.

Meetings

The Central Section of the SMPTE has scheduled two papers for its meeting at the Bell & Howell Co., 7100 McCormick Blvd., Chicago, on March 27. Bruno G. Staffen, development engineer of the Jensen Manufacturing Co., will describe a new low-cost theater speaker system, and there will be a description of the new Bell & Howell magnetic and optical 16mm sound projector by J. B. Weber, H. H. Brauer, F. J. Schussler and M. G. Townsley. C. E. Heppberger is Central Section Chairman, and John S. Powers is Program Chairman.

The Atlantic Coast Section of the SMPTE will meet on April 16, 7:30 P.M., at the Henry Hudson Hotel, New York City, when Robert Dressler of Paramount Pictures Corp.'s Chromatic Television Laboratories will present a paper and a demonstration on electrooptic sound recording on film.

71st Semiannual Convention of the SMPTE, April 21–25, The Drake, Chicago

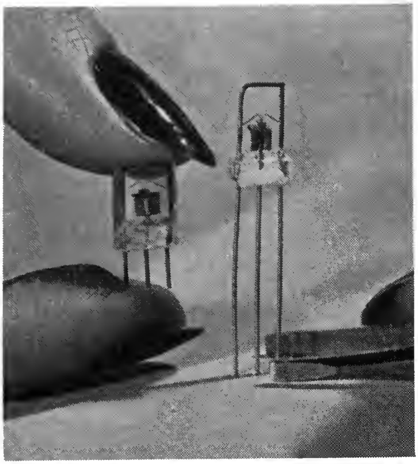
Other Societies

American Physical Society, Mar. 20–22, Columbus, Ohio
Optical Society of America, Mar. 20–22, Hotel Statler, New York
American Physical Society, May 1–3, Washington, D.C.
Acoustical Society of America, May 8–10, New York
American Institute of Electrical Engineers, Summer General Meeting, June 23–27, Hotel Nicollet, Minneapolis, Minn.
American Physical Society, June 30–July 3, Denver, Colo.
National Audio-Visual Association, Convention and Trade Show, Aug. 2–5, Hotel Sherman, Chicago
Photographic Society of America, Annual Convention, Aug. 12–16, Hotel New Yorker, New York
American Institute of Electrical Engineers, Pacific General Meeting, Aug. 19–22, Hotel Westward Ho, Phoenix, Ariz.
Illuminating Engineering Society, National Technical Conference, Aug. 27–30, Washington, D.C.
International Society of Photogrammetry, Conference, Sept. 4–13, Hotel Shoreham, Washington, D.C.

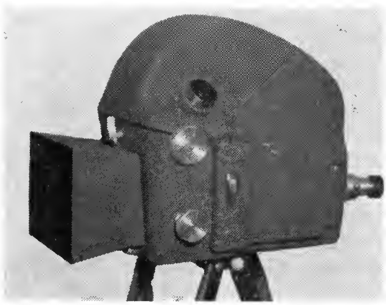
Test films are the customary tool for checking picture and sound performance in theaters, service shops, in factories and in television stations. Twenty-seven different test films in 16mm and 35mm sizes are produced by the Society and the Motion Picture Research Council. Write to Society Headquarters for a free catalog.

New Products

Further information about these items can be obtained direct from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of these items does not constitute endorsement of the products.



A developmental transistor was unveiled to the daily press during the last week of February, and the Camden, N.J., press department of RCA-Victor has released the accompanying photograph, which shows, in approximate life size, a transistor in an advanced stage of construction (right) and the finished transistor, with its components embedded in a protective casing of plastic (left). This transistor, based on the Bell Telephone Laboratories' development, is designed to perform many of the functions of a vacuum tube and can substitute for it in many applications. Because of its minute size and low power requirements, it is expected that it will make possible an important reduction in the size of many electronic devices used for television, radar and hearing aids.

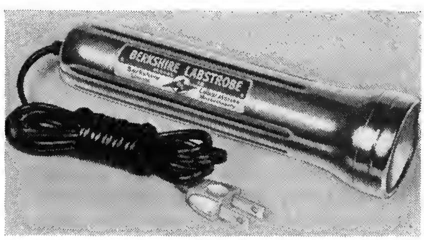


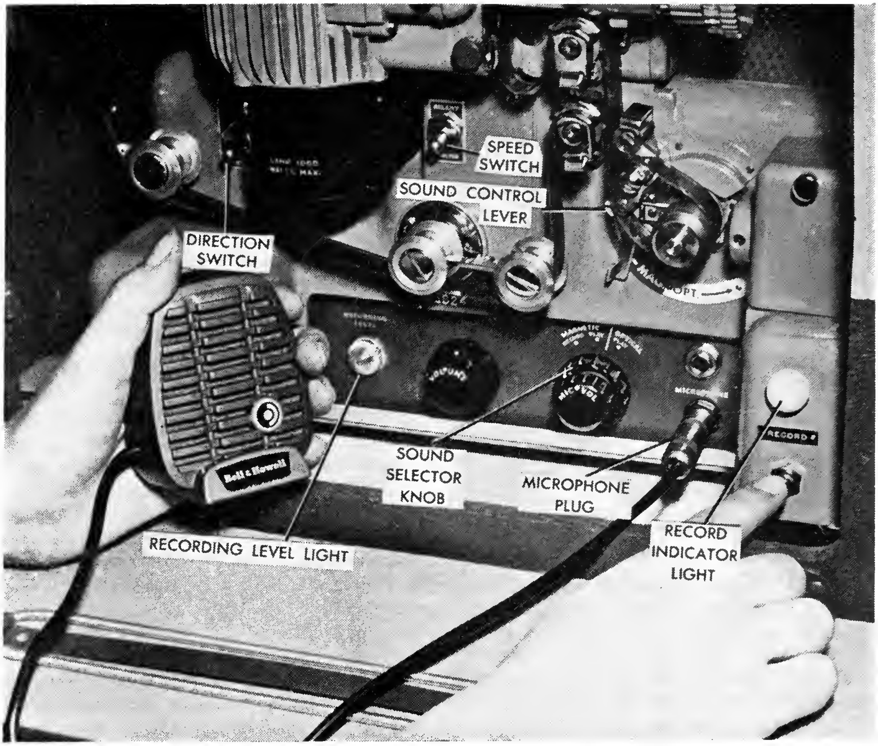
A light-weight sound-proof blimp for the Arriflex camera has been announced by Kadisch Camera & Sound Equipment Co., 128 West 48th St., New York 19, N.Y., manufacturer of the Arriflex. The blimp has an external control for follow-focus, and a built-in synchronous motor, and accepts 200- and 400-ft magazines. A new extension eyepiece through the blimp permits viewing through the lens during shooting. The new blimp is easily accessible for rapid changing of magazines.

The Berkshire Labstrobe, Model 18, has been designed as a small, light, economical stroboscope unit, using a standard neon bulb. It is available from the Berkshire Laboratories, 546 Beaver Pond Rd., Lincoln, Mass., with specifications:

Power source . . . . 115-v, 60-cycle, a-c
Power consumption . . . . less than 1 w
Flashing rate . . . . 60 cycles/sec
(determined by line frequency)
Flash duration . . . . . approx. 100 μsec
(measured at 50% of peak intensity)
Net price, f.o.b. Lincoln, Mass . . $9.95

The manufacturers suggest that it will prove useful for determining the speeds of rotation of motors, machines, phonograph turntables and other objects. The instrument is housed in a chromium-plated case and is the same size as a standard two-cell flashlight.





The Bell & Howell Filmosound 202 16mm optical-magnetic recording projector is now being marketed to non-professionals to make possible movies with sound at a cost of $200 for a 10-min film. Bell & Howell particularly emphasizes the usefulness of such an assembly to small manufacturing or marketing companies which make use of training and sales films, to educational and church users, to those who wish to exhibit films in a number of languages or dialects (as in India), etc.

The Filmosound magnetically records, plays back and erases, while the film is being projected, on single perforated color or black-and-white film which has been magnetically striped. Bell & Howell says that their Soundstripe will outlast the film, may be re-recorded indefinitely, and may be economically applied to the film at a cost of 3½¢ a foot. The Filmosound, which costs $699 with a 6-in. speaker contained in the case, operates for recording at either 16 or 24 frames/sec. A 12-in. auxiliary speaker is also available. Although the sound quality is better at 24 frames/sec, Bell & Howell reports that either gives acceptable results, equal to or better than commercially available disc recordings.

Soundstripe, which is a magnetic iron oxide stripe, may be striped over the full sound track area of single-perforated film; thus silent movies taken or duplicated on single-perforated film or optical sound film with obsolete sound tracks can be treated with full Soundstripe. Or half the sound track on optical film may be processed with the magnetic stripe, thus making it possible to record and play back the magnetic track or play back the optical sound track.

The Utility Television Monitor Model CA16 is now being produced by Conrac, Inc., 19217 East Foothill Blvd., Glendora, Calif. This monitor has been designed for general purpose use by television studios, both in control rooms and on stage, with these specifications reported: a fully rectangular picture presentation of 9 in. × 12 in. on the 16GP4 kinescope; wide-band video amplifier with a smooth roll-off above 7 mc; and a total of 14 tubes in addition to the kinescope.

Design features planned for the convenience of operating personnel are: coaxial input connectors and a switch to select either composite video, or separate video and composite sync; both inputs equipped with parallel receptacles for multiple connection; heavy-gauge steel cabinet housing with carrying handles; and a removable front to facilitate cleaning the kinescope face and the protecting safety glass.

The 1952 Catalog of Films From Britain is now available upon request to British Information Services, 30 Rockefeller Plaza, New York 20, N.Y. Nearly 300 16mm sound films are described. These are available as rentals or purchases from regional British Information Services offices and some dealers. In addition to a descriptive listing of all general and specialized films, the British Information Services reports that the special section "The Motion Picture—The Art and Its Artists (Experimental and Classic Documentaries, including Academy Award Winners)" was added in response to the requests of the many film societies, colleges and universities.

Six American Standards have been added to the Motion Picture Set of 60 which the Society has had available for sale. To holders of the present set the Society has made available the six new standards: PH22.11-1952, PH22.24-1952, PH22.73-1951, PH22.74-1951, PH22.76-1951 and PH22.82-1951. The price is $1 plus 3% sales tax on deliveries in New York City.

The new set of 66 standards in a heavy three-post binder with an index is available at $14.50 plus 3% sales tax on deliveries in New York City; foreign postage is $.50 extra.

All standards **in sets only** are available from Society Headquarters. Single copies of any particular standard must be ordered from the American Standards Association, 70 East 45th St., New York 17, N.Y.

Back issues of the Journal available: Don Canady, 5125 Myerdale Drive, R.R. 15, Cincinnati 36, Ohio, desires to dispose of a complete set, in excellent condition, from January 1930 to date, plus one issue of September 1928. Anyone interested in acquiring the complete set should communicate directly with Mr. Canady.

SMPTE Officers and Committees: A new roster of Society Officers and the Committee Chairmen and Members will be published in the April *Journal.*

The Nature and Evaluation of the Sharpness of Photographic Images

By G. C. HIGGINS and L. A. JONES

The ability of a photographic material to produce pictures having good definition is commonly referred to as its sharpness, which is a subjective concept. The objective quantity $\langle G_x^2 \rangle_{Av} \cdot DS$ is shown to be a physical measurement which correlates with sharpness judgments. $\langle G_x^2 \rangle_{Av}$ is the mean of the square of the density gradients, $\Delta D/\Delta x$, across an abrupt boundary between a light and a dark area in the developed image and DS is the density difference between these areas. $\langle G_x^2 \rangle_{Av}$ is evaluated only for those values greater than 0.005 in density per micron which represents the threshold gradient. It is shown that, contrary to the generally accepted belief, resolving power does not correlate well with sharpness judgments and in some cases is even misleading.

An important property of a photographic material is its ability to produce pictures having good screen definition. This property of a material is commonly referred to as its sharpness. Sharpness defined in this manner is a subjective concept.

The obvious usefulness of an objective measurement which will predict the sharpness of pictures made on a photographic material led to an investigation of the nature of sharpness and the physical properties of the picture which are important in producing sharp images.

Communication No. 1459 from the Kodak Research Laboratories, a paper presented on October 15, 1951, at the Society's Convention at Hollywood, Calif., by G. C. Higgins and L. A. Jones, Eastman Kodak Company, Kodak Park Works, Rochester 4, N.Y.

During the course of an investigation by Jones and Higgins[1] on photographic graininess and granularity, the mode of functioning of the human visual mechanism was examined in some detail.

It is generally accepted that the magnitude of the neural response, which initiates the sensory or perceptual response which occurs when a cone in the eye is stimulated, is determined by the suddenness with which the stimulation changes. The cones, which are the receptors in the eye for photopic or daylight vision, therefore respond primarily to temporal illuminance gradients, $\Delta B/\Delta t$. When examining any object in a visual field, the eye is constantly moving, with the result that the cones repeatedly scan the image formed on the retina. The distribution of luminance in the object produces a

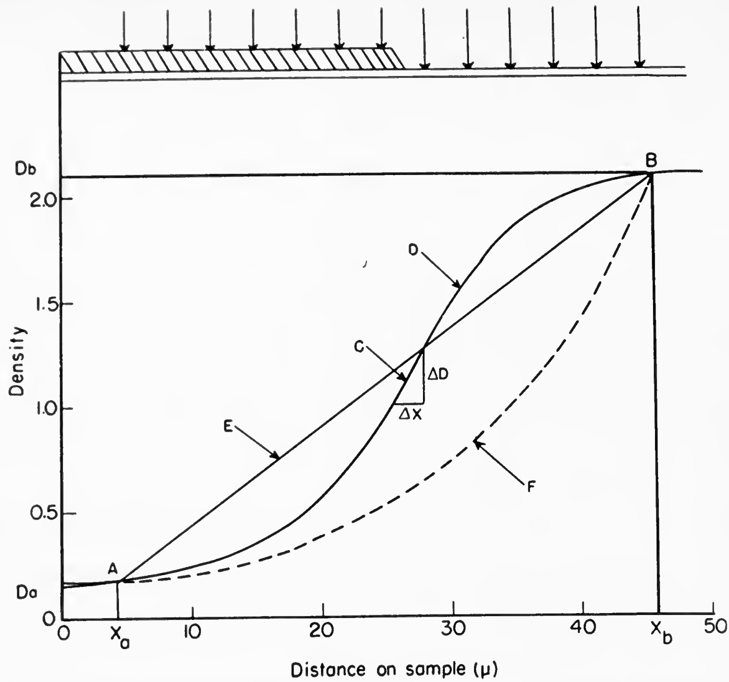


Fig. 1. Schematic diagram representing a knife-edge exposure and the microdensitometer trace, D, across the developed image. The straight line, E, between points A and B and the hypothetical dotted curve, F, represent traces having the same average gradient as curve D.

distribution of illuminance in the image formed by the lens of the eye. The motion of the eye then permits each of the cones to scan this illuminance distribution, the response of the cones being produced by the temporal illuminance gradients, $\Delta B/\Delta t$. This temporal luminance gradient consists of two components, the temporal component, $\Delta x/\Delta t$, produced by eye motion, and the spatial component, $\Delta B/\Delta x$, produced by the object being viewed, the product of the two components being $\Delta B/\Delta t$. The spatial luminance gradients, $\Delta B/\Delta x$, in the visual field therefore represent the physical aspects of the object which control the perception of detail.

The concept of gradient sensitivity has proved useful in finding an objective measure of a granularity which correlates with graininess. It appeared logical, therefore, to apply the gradient sensitivity principle to the problem of obtaining a physical measurement which will correlate with sharpness judgments of pictures.

When a photographic material is exposed while partially shielded by a knife-edge in contact with the emulsion, as shown schematically at the top of Fig. 1, the developed image does not end abruptly at the knife-edge but encroaches on the shielded area and has a diffuse boundary. A microdensitometer trace across a knife-edge image, made as shown schematically at the top of Fig. 1, is represented by curve D in the lower part of this figure. The ordinates represent density and the abscissas, distance on the sample in microns. When judging the

sharpness of this image, the cones of the eye move back and forth across this boundary in much the same manner as the fingers move back and forth across a piece of cloth when judging its roughness. The density gradients, $\Delta D/\Delta x$, across this boundary become log illuminance gradients, $\Delta \log B/\Delta x$, in the image formed on the retina. The motion of the eye converts these spatial log illuminance gradients into temporal log illuminance gradients which are the stimuli for the cones. The gradients are evaluated in terms of $\Delta D/\Delta x$ rather than $\Delta T/\Delta x$, since the response of the eye to luminance differences is known to be essentially logarithmic.

It has been suggested that the maximum value of the gradient, $\Delta D/\Delta x$, as shown at C, should be an indication of the sharpness of the image. However, experiments by Wolfe and Eisen[2] in these Laboratories have shown that the maximum gradient does not correlate with sharpness judgments. These same investigators have shown that the average gradient between any two points on this curve, such as A and B, also fails to correlate with sharpness judgments.

The average gradient, $\langle G_x\rangle_{\mathrm{Av}}$, between A and B is independent of the density distribution between the points. Curve D, which represents a microdensitometer trace, the straight line, E, between A and B, and the hypothetical dotted curve, F, all give the same value of average gradient, $\langle G_x\rangle_{\mathrm{Av}}$. If the physical aspect of the sample which determines the response of the cones is $\Delta D/\Delta x$, then the sharpness of the image should depend upon the rate at which the gradient changes across the edge. That is, the distribution of density across the edge represented by the three lines joining the points A and B should lead to three different sensations of sharpness. From the study of gradient sensitivity in connection with the investigation of graininess and granularity, it is known that the threshold gradient sensitivity in the photopic range is approximately 0.005 in density per micron. However, this threshold gradient, as indicated by the points A and B, is only an approximation and may have to be modified as more data are accumulated.

While there are numerous methods of evaluating the gradients in such a manner that the results will depend upon their distribution across the boundary, we have chosen to use the mean of their squares between the limits of 0.005 per micron. This average, $\langle G_x^2\rangle_{\mathrm{Av}}$ is equal to $\int_A^B (dD/dx)^2 dx/(X_b - X_a)$. We chose to use $\langle G_x^2\rangle_{\mathrm{Av}}$ since it is equal to the product of the average gradient measured at equal increments of D and the average gradient measured at equal increments of x; $\langle G_x^2\rangle_{\mathrm{Av}} = \langle G\rangle_{\mathrm{Av}(D)} \cdot \langle G\rangle_{\mathrm{Av}(x)}$. It seems probable that in obtaining the average gradient, its evaluation should depend upon equal increments of D, since the problem involved is that of perceiving luminance differences and, for any given viewing condition, ΔD corresponds to a difference in log illuminance on the retina. This method of averaging has been found to yield fruitful results in obtaining a numerical specification of the contrast of printing papers, which is a somewhat similar problem.

On the basis of the knowledge of the mode of functioning of the eye, it seems probable that the subjective impression of sharpness should depend not only upon $\langle G_x^2\rangle_{\mathrm{Av}}$, but also upon the density difference, DS, between the light and the dark areas. On the trace shown in Fig. 1, DS is equal to $D_b - D_a$. The objective quantity, $\langle G_x^2\rangle_{\mathrm{Av}} \cdot DS$, was therefore investigated as a physical measurement which it seemed reasonable to expect to correlate with picture sharpness. We suggest that physical measurements based upon the density variation across a knife-edge image be termed "acutance." The formula $\langle G_x^2\rangle_{\mathrm{Av}} \cdot DS$, therefore, gives values of acutance.

Wolfe and Eisen[2] prepared matched transparencies of the same scene printed on fine-grain positive film from ten different negative materials. The sharpest

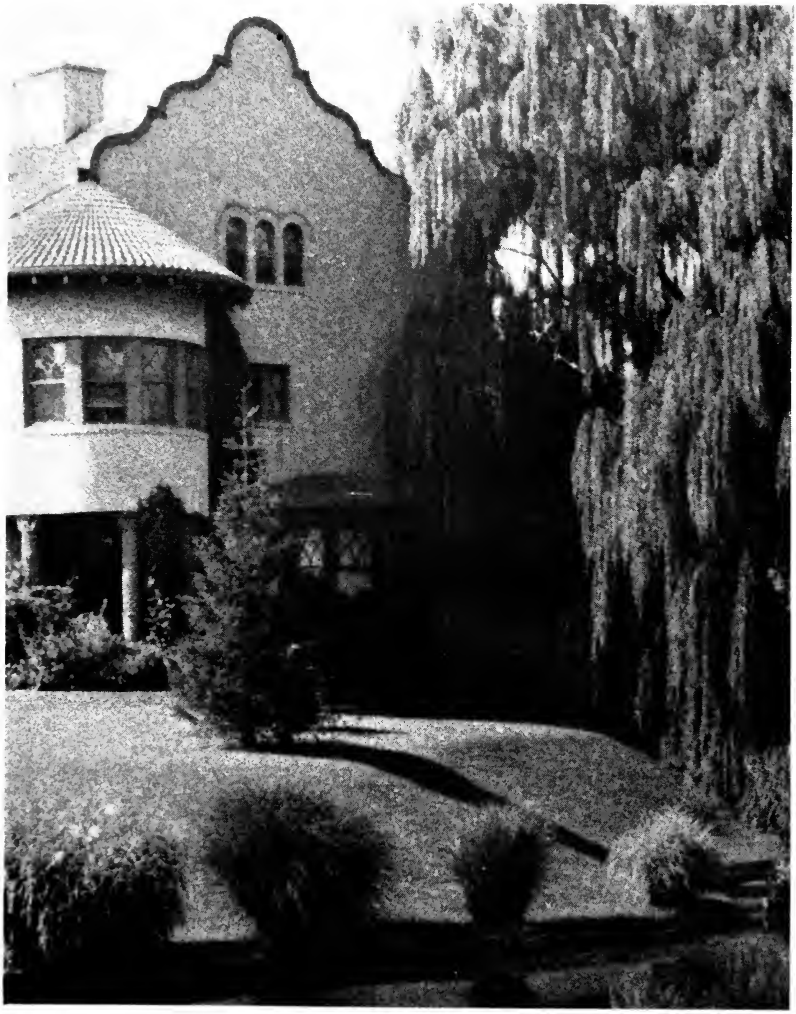


Figure 2A

Fig. 2. The sharpest (B) and the least sharp (A) pictures made from negatives on ten different photographic materials.

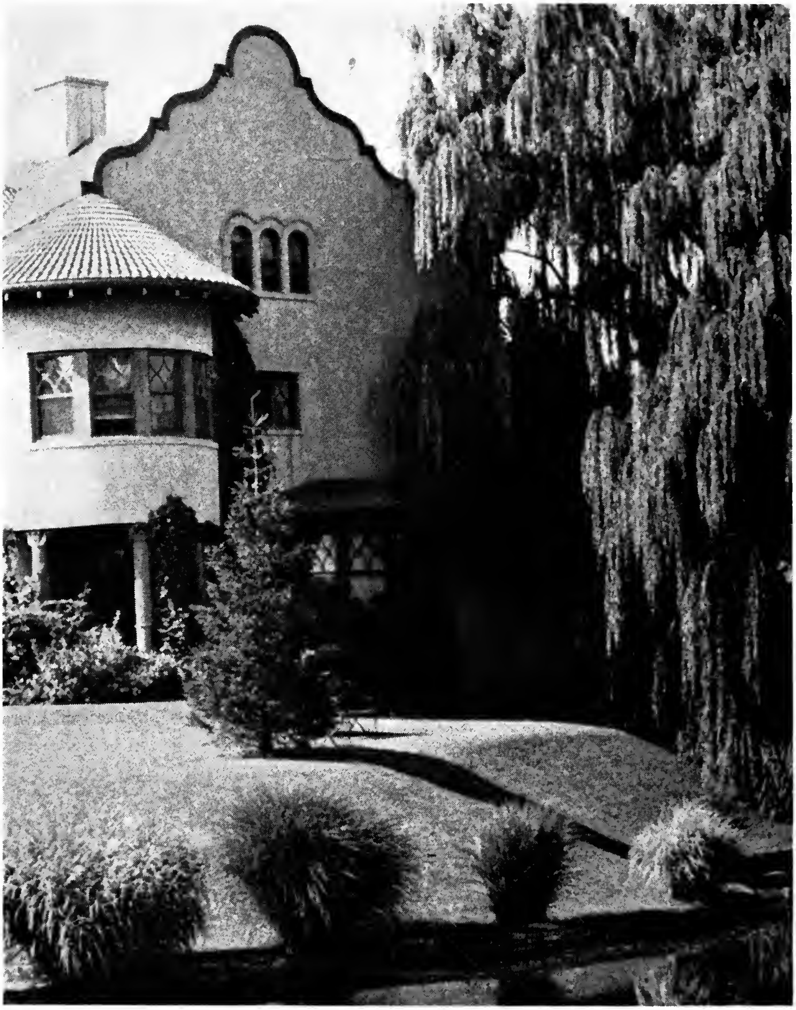


Figure 2B

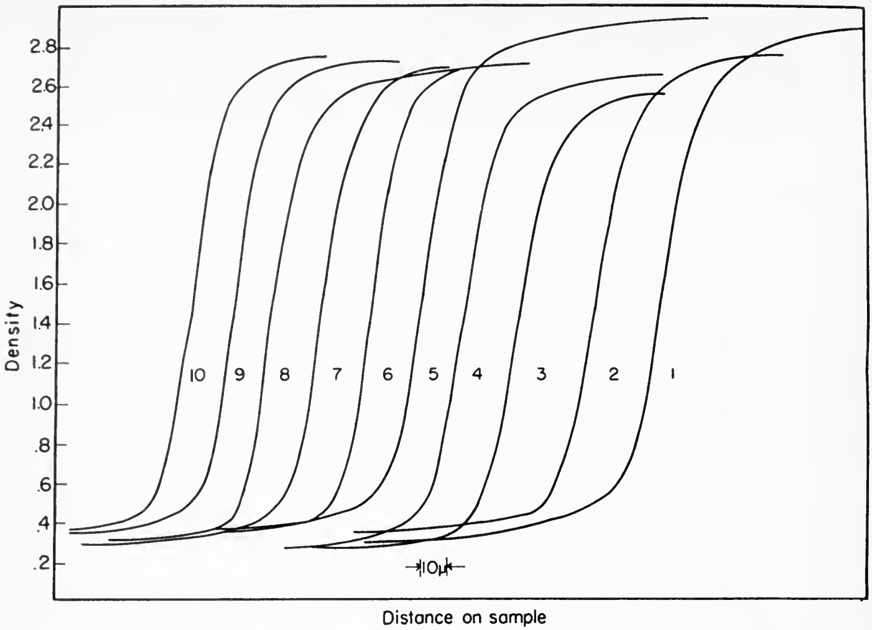


Fig. 3. Microdensitometer traces across the images in the positive as printed from knife-edge images on ten different negative materials.

picture, B, and the least sharp, A, made from these negatives are shown in Fig. 2. It is evident that the maximum difference in sharpness between the pictures made on these ten materials is relatively small. By subjective judgments of the relative sharpness of the positives from the ten negative materials, Wolfe and Eisen assigned numerical sharpness values to all positive transparencies. This method, which is an introspective psychological one, yields numbers of a purely ordinal nature which are not related to the objective character of the stimulus. The differences in sharpness in many instances were so small that different observers ranked a given pair of pictures in different orders, even though, based on the judgment of all observers, there was a real difference in sharpness between the two reproductions.

Knife-edge images were printed onto all negatives, and these images in the negative were, in turn, printed by contact onto fine-grain positive film. The microdensitometer traces across the knife-edge images in the positive are shown in Fig. 3. While the differences in the traces appear quite small, curve 10, which represents the trace on the sharper picture in Fig. 2, shows a higher slope and a more abrupt toe and shoulder than curve 1, which represents the trace on the least sharp picture shown in Fig. 2. As noted previously, the maximum slope of the curves does not correlate with sharpness. For example, curves 3 and 4 have essentially the same maximum slope, while all observers find pictures on material 4 sharper than on material 3. The significant difference between these two curves is the rounding-off of the shoulder and the slightly lower density scale on curve 3 as compared with curve 4.

The acutance values, $\langle G_x{}^2\rangle_{Av} \cdot DS$, were calculated for all traces and are plotted as a function of sharpness in Fig. 4.

The coefficient of correlation between the objective and the subjective measurements is 0.994. The relation shown in Fig. 4 is psychophysical, since it shows the correlation between a subjective (psychological value) and an objective (physical) factor. All materials are ranked in the same order and are spaced approximately the same on the sharpness scale. The very small difference in sharpness between prints from negative materials 1 and 10, as shown in Fig. 2, is represented by an acutance difference of 1620 or more than 100% of 1350, the value for the least sharp material.

For many years it has been the practice in the photographic field to report values of maximum resolving power for the different materials. Resolving power is usually measured by photographing a series of line gratings and determining the number of equal-width lines and spaces that are just resolvable when the developed image is examined visually under adequate magnification. While these measurements were intended specifically as a measure of the ability of the film to record fine detail, such as images of double stars or fine parallel lines, it has been generally assumed that these resolving-power values were a measure of the ability of the material to produce sharp pictures. However, experience has shown that resolving power as usually measured does not correlate well with sharpness judgments and in some cases may even be misleading.

The lack of correlation between resolving power and sharpness is strikingly shown by the prints in Fig. 5. The same negative was printed onto two experimental positive materials to give the best-matched tone reproduction possible. The positive material used in printing picture A has a maximum resolving power in excess of 230 lines per millimeter, while the positive material used in printing picture B has a maximum resolving power of 130 lines per millimeter. Even though the material used in making print B has a very much lower resolving power,

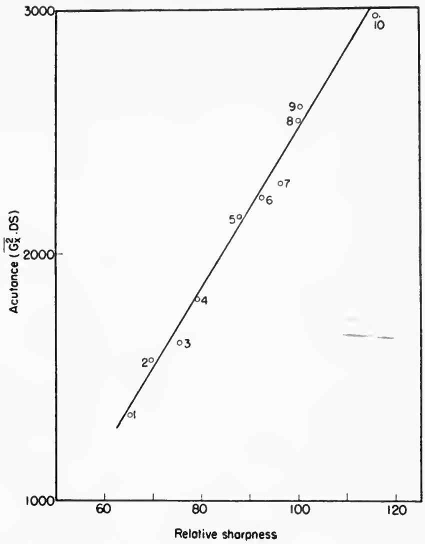


Fig. 4. Acutance, $\langle G_x{}^2\rangle_{Av}\cdot GS$, plotted as a function of sharpness.

the picture is clearly much sharper than print A, obtained by printing on the high-resolving-power material. When making the pictures shown in Fig. 5, knife-edge images were printed onto the two positive materials. The microdensitometer traces across these knife-edge images are shown in Fig. 6. The difference between these two traces is readily apparent. Trace A, representing the less sharp material, has a very low slope and a long toe and shoulder, while trace B, representing the sharp material, has a relatively high slope and an abrupt toe and shoulder. The density scales are essentially the same for both materials. The value of $\langle G_x{}^2\rangle_{Av}\cdot DS$ for the very sharp material is 12,210, while the value for the unsharp material is only 2,800.

The basic principle underlying the method of obtaining a physical measurement correlating with sharpness judgments of the photographic image should also apply to the evaluation of lenses where the luminance gradients of importance are those in the areal image formed

Figure 5A

Fig. 5. Prints from the same negative printed onto two experimental positive materials; material A having a maximum resolving power of 230 lines per millimeter and material B, a maximum resolving power of 130 lines per millimeter.

Figure 5B

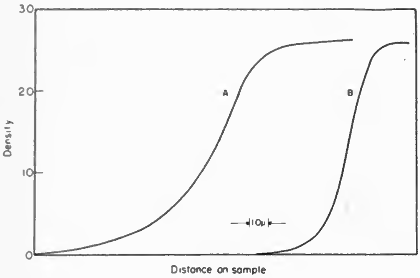


Fig. 6. Microdensitometer traces across knife-edge images printed onto the two positive materials used in making the pictures shown in Fig. 5.

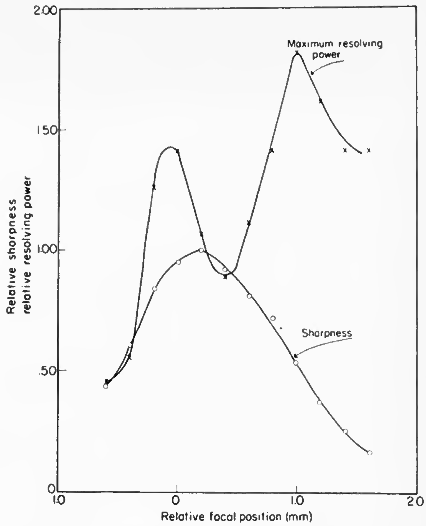
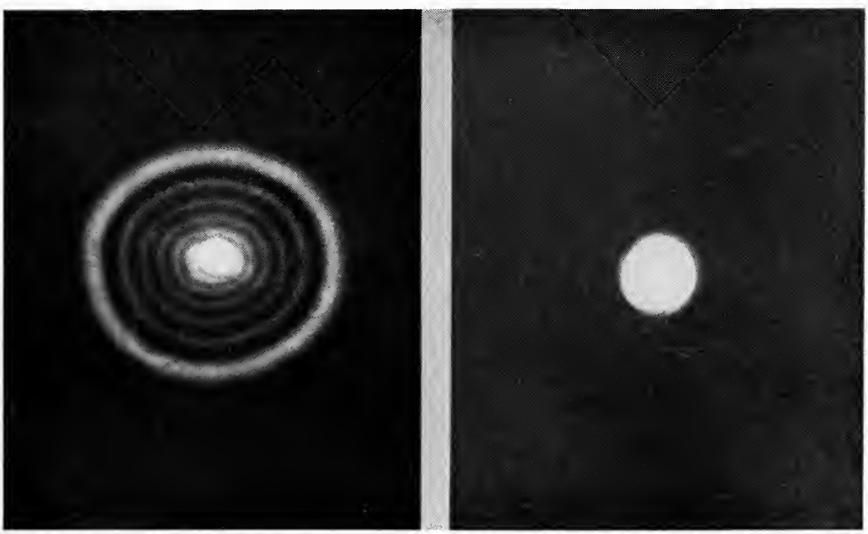


Fig. 7. Maximum resolving power and relative sharpness of pictures plotted as a function of the relative distance from lens to film when making the negatives.



A

B

Fig. 8. Photographic reproductions of the image of a point source as formed with a lens. B was made at the image distance giving maximum sharpness, and A was made at the image distance giving maximum resolving power.

by the lens. From the standpoint of photographic reproductions it is, of course, also necessary to examine the manner in which these luminance gradients in the areal image are reproduced as density gradients in the negative and in the positive. Wolfe and Eisen[3] examined a 12-in. lens designed for aerial photography by photographing the same picture repeatedly, the photographic material being placed at different distances from the lens. These negatives were then printed onto photographic paper and the resulting prints were judged for sharpness. A standard resolving-power test chart was also photographed under the same conditions employed in making the picture negatives. Maximum resolving power, as measured with a high-contrast test object, and relative picture sharpness are plotted as functions of image distance in Fig. 7. The abscissa values represent distance in millimeters from an arbitrary origin. As shown, the position of maximum resolving power is approximately 1 mm. from the position of maximum sharpness.

Wolfe and Eisen[3] also photographed a point source and a knife-edge under the same conditions that were employed in making the picture negatives. Photographic reproductions of the images of the point source are shown in Fig. 8. At the position of maximum sharpness, shown at B, the image of the point is fairly large but has very sharp edges, with practically no variation in density outside the central image, while at the position of maximum resolving power, shown at A, the image of the point is represented by a small dot surrounded by relatively large variations in density in the form of several light rings. Microdensitometer traces across the knife-edge images are shown in Figure 9. The trace made at the position of maximum sharpness, B, has a very high slope and a little toe or shoulder, while the trace made at the position of maximum resolving power, A, has a relatively low slope and a very pronounced toe and shoulder.

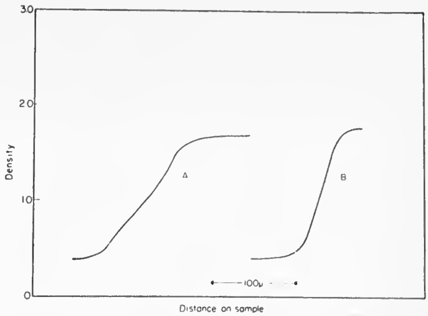


Fig. 9. Microdensitometer traces across photographic reproductions of the knife-edge image as formed with a lens. B was made at the image distance giving maximum sharpness, and A was made at the image distance giving maximum resolving power.

The values of $\langle G_x{}^2 \rangle_{Av} \cdot DS$ as obtained from the traces representing maximum sharpness and maximum resolving power are 620 and 165, respectively. The acutance criterion indicates the focal positions giving maximum sharpness, while the criterion of maximum resolving power represents a focal distance 1 mm removed. The pictures shown in Fig. 10 were made with the film at the position of maximum sharpness, B, and at the position of maximum resolving power, A.

All data taken to date indicate that acutance measured as $\langle G_x{}^2 \rangle_{Av} \cdot DS$ can be used to predict the sharpness of pictures made with different photographic materials. The data also indicate that this concept is useful in evaluating the sharpness characteristic of an image produced by a lens. However, the density difference, DS, across the knife-edge image is essentially the same for all samples investigated. The data, therefore, are not conclusive as to whether the DS term should be introduced, or if so, whether it should be introduced as a weighted function.

While it is shown that resolving power as usually measured cannot be used to

Figure 10A

Fig. 10. Photographic reproductions of the same scene made at the image distance giving maximum sharpness, B, and at the image distance giving maximum resolution, A.

Figure 10B

predict with certainty the ability of a photographic material or a lens to produce sharp pictures, it is nevertheless an important property of the materials. When viewed at 14 in. under optimum conditions, the eye can resolve a maximum of about ten black and white lines per millimeter. The resolving power of the film or lens must be sufficient to satisfy the limit set by the eye for a given viewing condition. We believe that, from the standpoint of sharpness, the important property of the image is the acutance of the edges of lines which are just resolved by the eye. Acutance measurements on lines of different widths and different frequencies, as well as different contrasts, should give this information. Resolving power is therefore a limiting condition which does not furnish information as to the sharpness of detail which is well resolved by the eye.

References

1. Loyd A. Jones and George C. Higgins, "Photographic granularity and graininess: III. Some characteristics of the visual system of importance in the evaluation of graininess and granularity," *J. Opt. Soc. Am.*, *37*: 217–263, Apr. 1947.
2. R. N. Wolfe and F. C. Eisen, unpublished work.
3. R. N. Wolfe and F. C. Eisen, unpublished work.

Progress in Three-Dimensional Films at the Festival of Britain

By RAYMOND SPOTTISWOODE

The planning for the Telecinema is described, then the building and the projection equipment. Also discussed are the developing of stereoscopic cameras and new formulas, producing the films, and introducing stereophonic sound and large-screen live television shows. The success of various parts of the program is evaluated and possibilities for the future assessed.

The Festival of Britain, 1951, was planned as a mid-century stock-taking of Britain's achievements in the arts and sciences, combined with an attempt to pierce into the future and foreshadow the developments of the next 50 years. The Great Exhibition of 1851 had stuck obstinately to the present; in fact it had dismissed electricity as a mere toy, and had treated the finding of oil as no more than a convenient replacement for candles. The planners of 1951 were determined not to be caught napping. Their centerpiece was an exhibition site on the South Bank of the Thames in London; and here, in a series of daringly executed buildings, they presented thematically the story of the people of Britain, their origin, their environment, their way of life, their discoveries.

From the very beginning, the motion picture had its place in this thematic treatment. Despite periodic ups and downs, British studios have made notable contributions to the art of the film, and these were commemorated in 1951 by a cooperative production, *The Magic Box*, which told the story of William Friese-Greene, one of the pioneers who aided in the invention of the movie camera.

The Festival authorities provided on the South Bank a new building, the Telecinema, and a new program in which, for the first time in the world, live big-screen television and three-dimensional films were to be combined on an equal footing as an entertainment foreshadowing the movies of the future.

Glancing ahead for a moment, it may be recorded that the Telecinema and its program was one of the outstanding successes of the Festival. With only

Presented on October 19, 1951, at the Society's Convention at Hollywood, Calif., by David R. Brower, Assistant to the Manager, University of California Press, Berkeley, Calif., for the author, Raymond Spottiswoode, Kingsgate, Sudbury Hill, Harrow-on-the-Hill, England, who was Technical Director, Stereofilm Program, Festival of Britain, 1951.

Fig. 1. The Telecinema building.

400 seats, it grossed in five months about $225,000, converted at the old rate of exchange normally used for economic comparisons. The total audience was very nearly half a million; but this could have been greatly increased, if the Festival had not had commitments to include in the program a number of documentary films which had been specially produced for it. As it was, with seven to nine shows a day, the public had to queue for between one and three hours to get in — a period often very much longer than that of the program itself. Yet throughout the 22 weeks, there was not a single complaint, and many people returned to the Telecinema again and again.

In the short space of this paper, I shall try to describe the Telecinema building and the events which led up to the completion of the 33-min series of stereoscopic and stereophonic films. If I say little about television — for which 1,220 live shows were produced — it is only for lack of space; it played a vital part in the construction of our programs.

The Building

Work on the Telecinema was started late in 1949. The Festival was extremely fortunate in its choice of architect. Wells Coates, though hampered by a narrow site pressed close against a railroad bridge, succeeded in producing a building of elegant and simple lines, with a seating capacity of 400 and adequate space for the many supplementary services required (Fig. 1). The inside of the theater (Figs. 2 and 3) is austerely simple, but it is saved from any feeling of severity by its attractive color scheme of varying shades of blue. The Festival motif was introduced in a Venetian-blind curtain of original design. The building was laid out exclusively for use with modern safety-base film, thus allowing certain precautionary measures to be dispensed with, and permitting a type of construction (sometimes from its shape called "lobster-

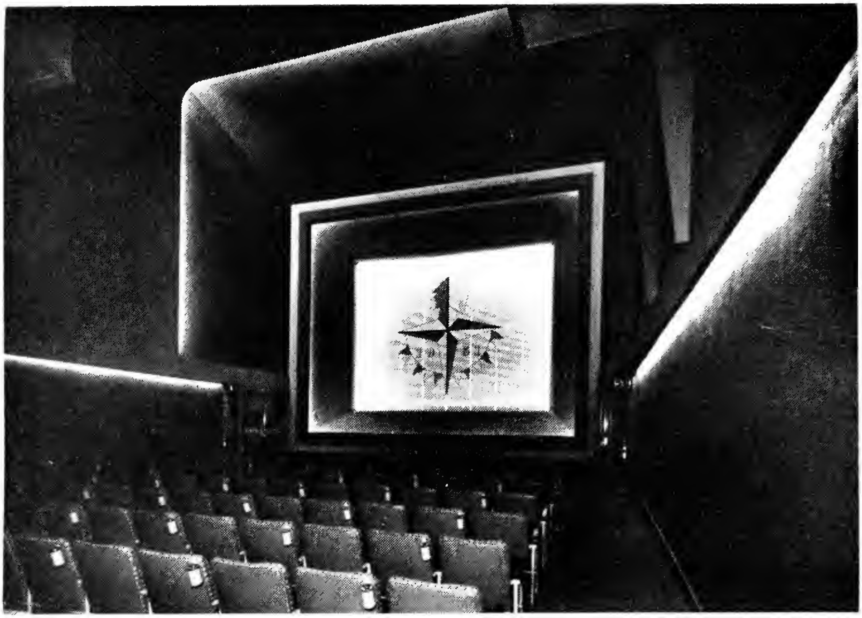


Fig. 2. Interior of the Telecinema — view from the stalls.

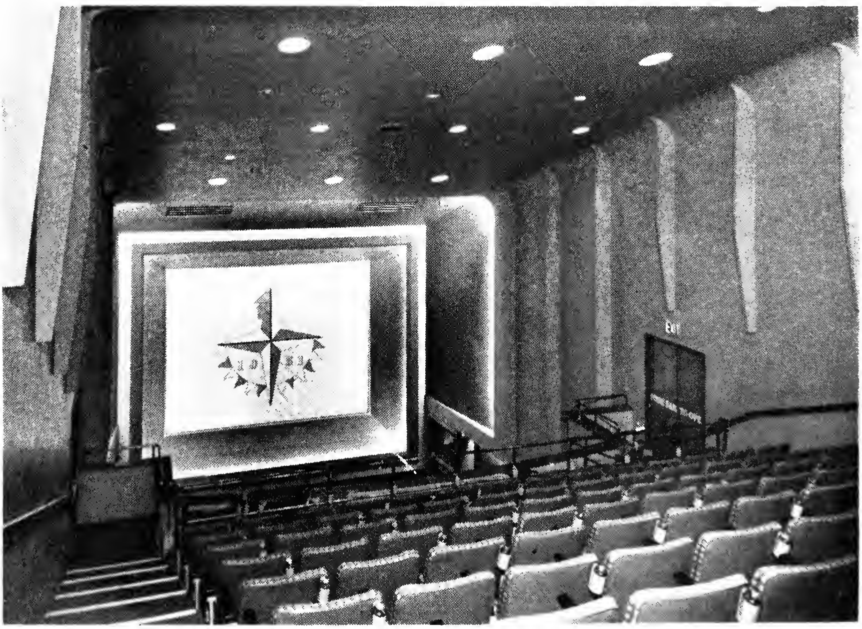


Fig. 3. Interior of the Telecinema — view from the circle.

claw") in which the projection room is enclosed in the space between the upper and the lower tiers of seats (see Fig. 4). This gives a horizontal projection beam, with a picture free from keystone distortion, and also provides a platform within 45 ft of the screen for mounting out of sight the Schmidt-type television projection equipment. In the Telecinema, this projector (built by Cinema-Television, Ltd.) was placed centrally, and was swung out of the way for film projection by means of a turntable and rails. This structural arrangement necessitates a rather high position for the screen, and the front seats in the theater are accordingly given a reversed slope. The Stableford screen was of the high-gain, non-depolarizing type, equally suitable for television, three-dimensional and flat films, and, in spite of the metallic surface, a remarkably wide light distribution is secured by special design. Uniform screen brightness from the side front seats is aided by giving the screen a slight cylindrical curvature of a radius equal to the projector throw. Though the screen itself has a width of 20 ft, the image width is only 15 ft, the remaining area forming a band around the picture which receives a diffused light picked up from the film itself and projected onto the screen by a device produced by the British Thomson-Houston Co.

Figure 5 shows the disposition of some of the equipment in the projection-room, as viewed through the large glass window which enables the audience when entering the theater to see "what makes the wheels go round." The television equipment consists of a camera and control console (not shown) which feed a video signal to the console on the extreme left, from which the signal passes to the projector placed immediately in front of the front wall of the projection room. The film projectors are BTH S/U/P/A machines synchronized by selsyn interlock, and behind them stand two BTH-HMV 4-track magnetic recorder-reproducers for handling the stereophonic sound tracks. Non-sync magnetic machines and complex switchgear complete the projection room installation.

This is the equipment which rendered such satisfactory service throughout the Festival in 1951. But in the early part of 1950 no equipment of any kind was available in England for producing or projecting stereoscopic and stereophonic films. All of it had to be designed and built, and the films produced, in only 14 months. First to be put in hand was the magnetic recording and re-recording equipment. In order to reduce inter-track magnetic interference, it was decided to employ no more than four sound tracks, the wide dynamic range making a control track unnecessary. Three of these tracks were to feed three banks of loudspeakers placed symmetrically across the screen (Fig. 6), the outer ones being set as far apart as possible to widen the sound base. Thus only a single track remained for feeding the groups of loudspeakers mounted and wired in parallel behind the balcony and stalls, and (again in parallel) in the main ceiling and in the ceiling of the rear stalls.

In the writer's opinion, the use of three channels behind the screen has not been adequately justified, the Philips company in Holland having given extremely convincing demonstrations of back-of-screen stereophonic sound employing only two channels, the center loudspeaker being fed with low-frequency nondirectional sound from a bridge circuit.

Shortly afterwards, construction work was started on a stereoscopic camera based on two Newman-Sinclair units facing inwards in conventional fashion toward a pair of mirrors, and so mounted that the inter-lens separation (stereo-base) could be varied from 1 to 8 in., and the half-angle of convergence (stereoangle) from 0° to 5°.

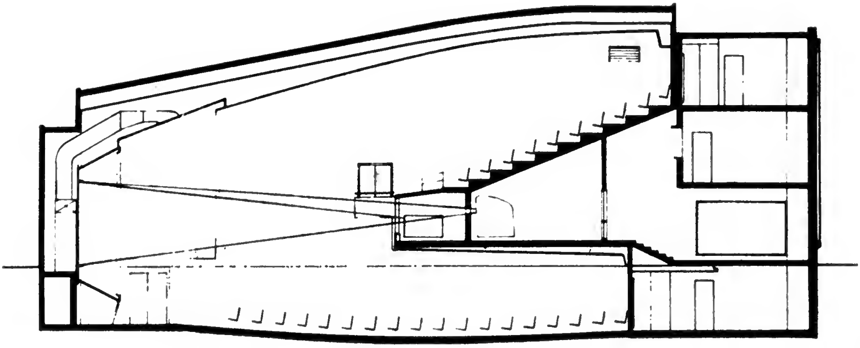


Fig. 4 Section of the Telecinema through center line.

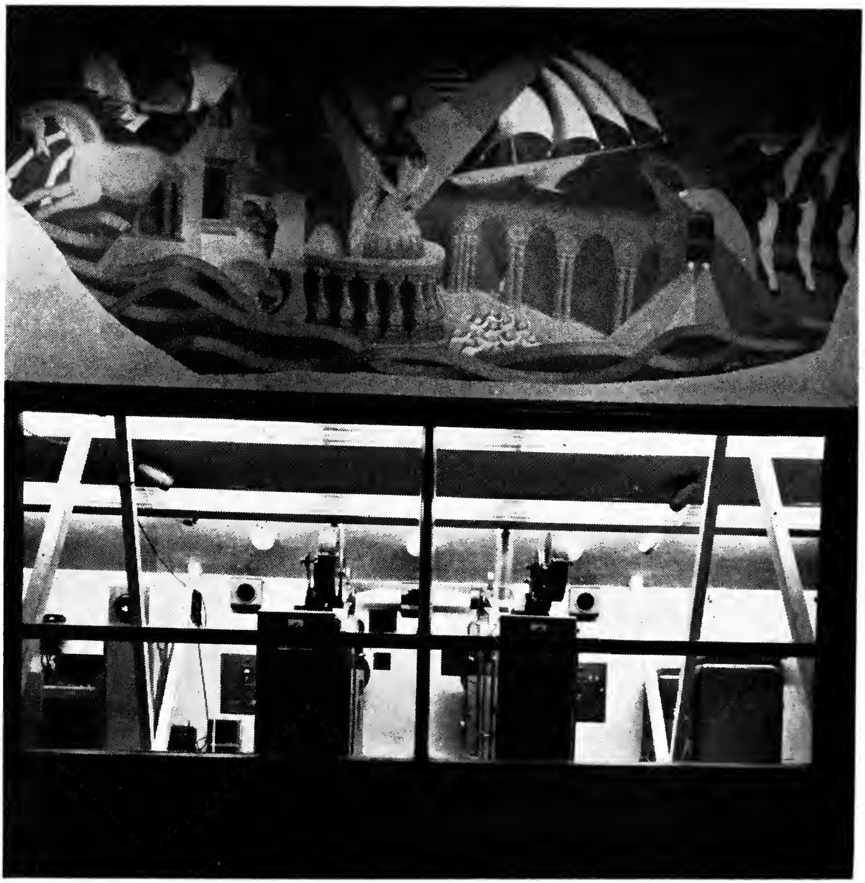


Fig. 5. Projection room as seen by those entering the Telecinema.

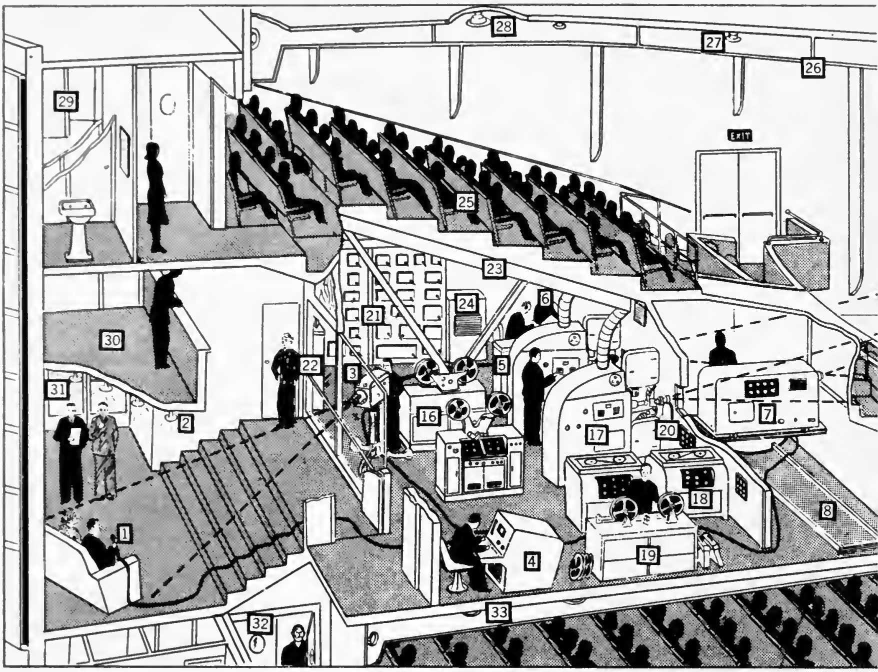


Fig. 6. Profile of the Telecinema.

Key to Television Operations

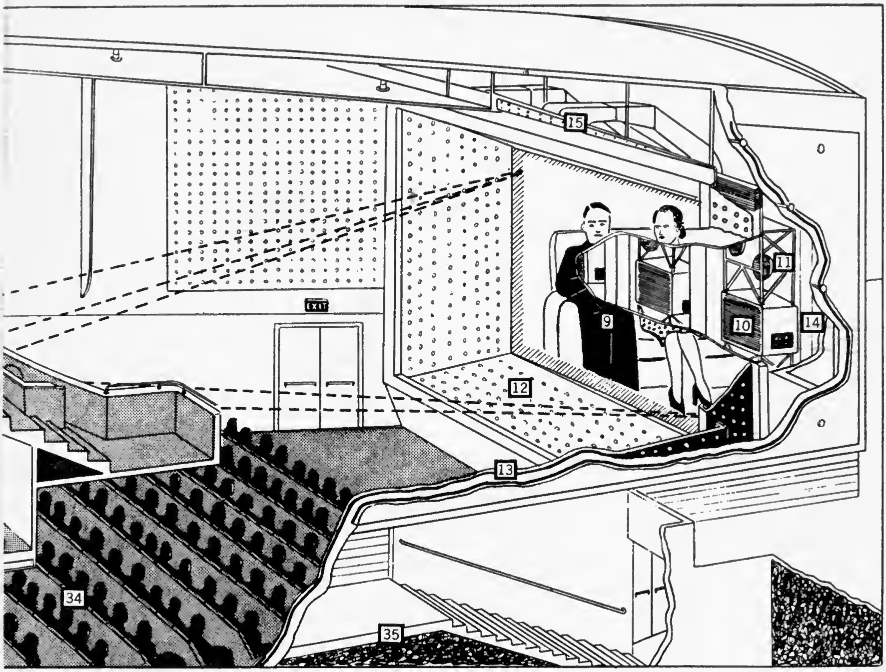
1. Scene being enacted in foyer of the theater.
2. Floodlights.
3. Television camera.
4. Sound monitor control.
5. Amplifiers.
6. TV control console.
7. TV projector.
8. Runway and turntable for TV projector when films are being shown.
9. Actual scene being taken in the foyer projected on to the high-grain screen simultaneously.
10. Main loudspeakers.
11. Auxiliary speakers which can control sound from any portion of the screen.
12. Sound frame funnels to audience.
13. Insulated main walls.
14. Insulated studs.
15. Air-control vents.

Key to Projection Room

16. Stereophonic four-sound-track magnetic reproducers, one of which is coupled to the two projectors.
17. Two projectors giving synchronous left- and right-eye pictures.
18. Interval music sound tracks.
19. Film rewinder.
20. Projector control panel.
21. Main switch gear.
22. Glass screen to foyer.
23. Vent from projectors.
24. Incoming B.B.C. Television to control console.

Other Parts

25. Balcony, 150 seats.
26. Suspended roof.
27. Roof lights.
28. Loudspeakers.
29. Entrance to balcony.
30. Mezzanine floor and manager's office.
31. Main entrance.
32. Entrance to stalls.
33. Loudspeakers.
34. Stalls, 252 seats.
35. Ground level and exit from stalls.



During the months that elapsed when this equipment was taking shape, two other projects were put in hand. In order to augment the program, it was decided to invite the National Film Board of Canada, known throughout the world for its experimental films, to undertake a three-dimensional abstract film with stereophonic music, the first to be made anywhere. Their response was most generous, and the film *Around is Around* (which was presented with the paper by McLaren[1] at this Convention) was put into production.

A Theory of Stereoscopic Transmission

Secondly, as a result of careful study of the literature of the three-dimensional film, it became apparent that knowledge of the transformations and distortions of the stereo image was still exceedingly scanty, and most of the recommendations were empirical, in spite of the excellent preliminary work carried out by Rule,[2] Norling[3] and others. The present writer, with his brother, N. L. Spottiswoode, therefore set about evolving a comprehensive theory of stereoscopic transmission, which is shortly to be published as a book of that name by the University of California Press. A single master equation determines the shape of the image under all possible variations in the camera and projection systems, while a series of about 80 subsidiary equations makes possible the design of convenient calculators, and elucidates many peculiarities of the three-dimensional image not hitherto studied.

The four films in our Telecinema program (widely different in their style and subject matter) were all produced in conformity with this theory. Today, the director of a three-dimensional film has only to state what position in the ultimate movie theater he wishes a landscape or a studio scene to occupy, in order to fit the mood or the editing of a sequence; and in a few moments

the stereotechnician beside the camera will have established the precise shooting conditions for realizing this intention. If, moreover, there are psychological factors which will tend to alter this geometrical placement of the image in cinema space, he will be able to make proper allowance for them. By the same token, the producer of an animated cartoon film (using standard one-lensed equipment) can now work with as much accuracy in three dimensions as he formerly did in two.

We owe it to the organizers of the Festival and to the British Film Institute that we were thus able to devote many months to a subject of no immediate utility, but which none the less greatly simplified the productions which were to follow, and which will, it is hoped, be of service to the industry in general if three-dimensional films come into widespread use.

Production

The special stereoscopic camera was not completed in time to shoot with it the Monopack Technicolor film which had been planned. Accordingly, the Newman-Sinclair cameras on their special base were allocated to the production of a black-and-white film which was shot in a week at the London zoo. The film is built round the character of an eminent professor who believes that an audience cannot appreciate a three-dimensional film unless it has first grasped the principles of stereoscopic transmission. (Any resemblance to the present writer is wholly coincidental!) While he becomes more and more mixed up in tangled phrases and demonstrations which don't come off, the camera cuts away to sequences which clearly show the heightened reality of the three-dimensional film.

To make possible the production of an actual film in color, Technicolor Ltd. of England came forward with the generous offer of two three-strip cameras mounted alongside one another on a base which permitted a variable angle of convergence. Figures 7 and 8 show this assembly from different angles. The simple device of a very slightly tapered wedge (Fig. 9) enabled the stereoangle to be adjusted with speed and accuracy. Parallax measurements under the traveling microscope showed that the actual parallaxes between infinity points on the two camera images differed by only 3 to 5 ten-thousandths of an inch from those arrived at by calculation. A universally jointed drive (Fig. 10) took care of the convergence angle and enabled one of the cameras to be swung aside for film inspection. The normal Technicolor selsyn system was employed to follow focus on the two cameras.

The only fundamental disadvantage of this excellent arrangement was the necessarily wide separation of the lens axes; with virtually no gap between the cameras, this distance was 9.5 in. This gave, in the theater, a stereoscopic width magnification (m_w) of about 0.25, and a depth magnification (m_d) at a mid-position in the theater of about an equal amount. This suggested that the film should be composed mainly of long shots, in which what we call extra-stereoscopic factors — perspective, masking, light and shade, and so on — should as far as possible counteract the miniaturizing effect produced by the exaggerated stereobase.

Our choice of subject fell on the headwaters of the River Thames, little known to Londoners, especially as they appear in the winter months, when the twin lenses of the stereo film camera, mounted on a moving platform, would reveal the receding planes of the bare tree branches in all their architectural beauty. Despite the worst March weather in 80 years, a short version of this film was produced in time for the Festival, and was entitled *The Distant Thames;* later a complete film, *Royal River*, took its place. In a questionnaire issued to audiences, this film received a

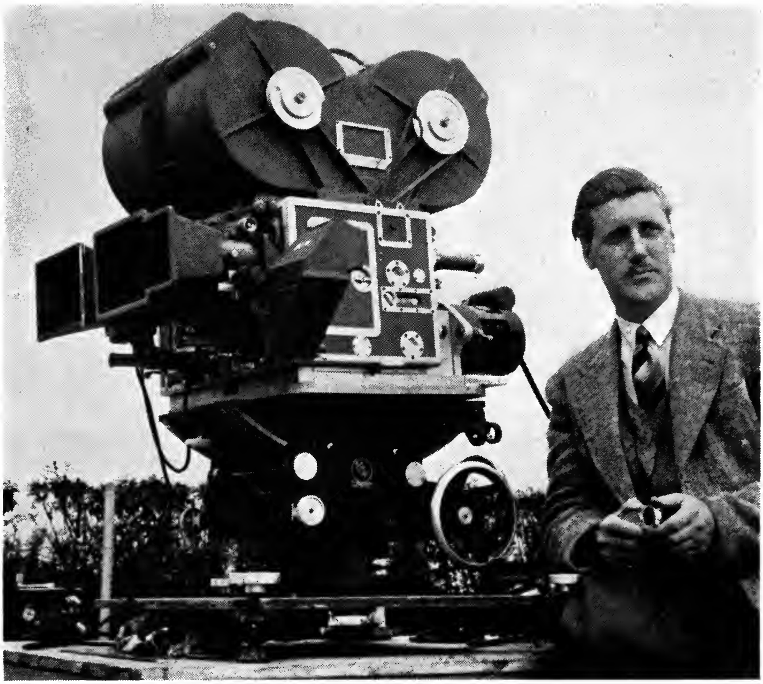


Fig. 7. Two three-strip cameras mounted together,
as supplied by Technicolor Ltd.

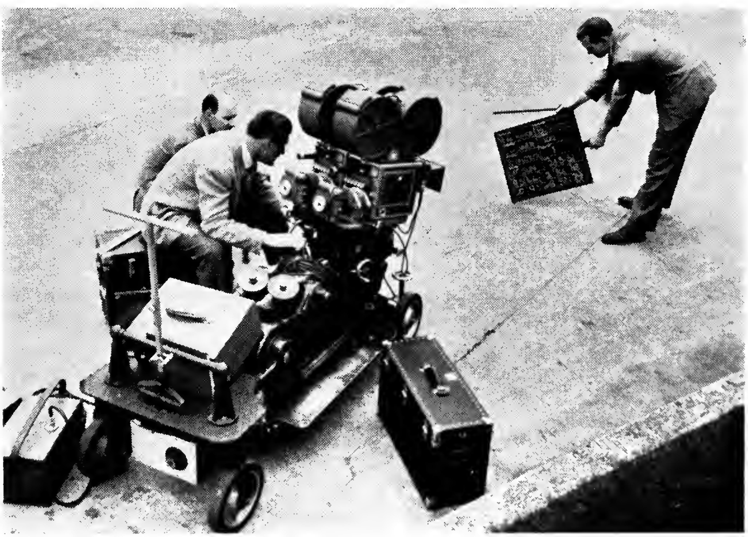


Fig. 8. Two three-strip cameras supplied
by Technicolor Ltd. showing dolly.

majority of first choices over all the other films in our program.

Stereophonic Sound

Royal River, *Around Is Around* and the short introductory film, *Now is the Time to Put on Your Glasses*, were all designed for stereophonic sound accompaniment. The equipment previously outlined was completed by a special re-recording console, the chief feature of which was a set of "pan-pots" similar to those designed by the Walt Disney studios for *Fantasia*. These are variable distribution networks which enable a single input to be "moved around" to any required output sound track and thus to any required group of loudspeakers. Re-recording was carried out in the Telecinema itself before the Festival opened, and afterwards during the night, when the building was closed to the public. In this way, the precise effect of the multiple sound tracks could be judged during mixing.

Reactions to Telecinema

The television and stereo program was first presented at a world press show in the Telecinema on April 30, 1951, and it may be of interest to analyze some of the widespread reactions. It was to be expected that certain of the more tradition-bound critics should regard the stereofilm as just one step nearer to complete naturalism, and they viewed with alarm the prospect of highly three-dimensional film stars should Hollywood take up this new kind of movie. For other reasons, the trade and technical press were not altogether sympathetic. For them the three-dimensional film meant a challenge to long-established entertainment values; without the blessing of the industry, it must be regarded as an attack from outside, like television. The first response was therefore to say that it had all been done before, and wasn't worth doing again.

The public, however, caring little for these aesthetic and commercial arguments, showed great enthusiasm for the new films, and there was in fact never an empty seat during all the 1,220 performances, despite the normal commercial admission charges. Certain of the critics, moreover, showed a welcome perception of new possibilities in film. The dignified *Times* declared,

> "[In *The Distant Thames*] the sight and the imagination were being drawn into depths and perspectives the screen has never before possessed the secret of revealing.... The impact of third-dimensional image and sound is far greater and more fascinating than expectation had imagined; the spectator who has once been lent a pair of those magic glasses and, by taking them, becomes a participant, will feel like a tiger who has tasted human blood and will be content with no other."

And, towards the end of its run, the Telecinema was described by a prominent trade paper as a gold mine, and the paper urged the industry to press ahead with the commercialization of large-screen television and three-dimensional films.

This response was the more gratifying since our program was extremely modest in scope and capable of great improvement in its entertainment value. If these little films, made on a budget of a few thousand pounds, could attract such enormous audiences, and cause an audible thrill to run through the house at each performance, what would not be the stimulating effect on the box office of three-dimensional films made with all the resources of Hollywood?

It is this thought which prompts the following tentative comments on the future of the stereofilm. On the most restricted scale, we are hopeful that the Telecinema will remain in existence under the progressive management of the British Film Institute as a place where three-dimensional films and live television can continue to foreshadow the entertainment of the future. Those

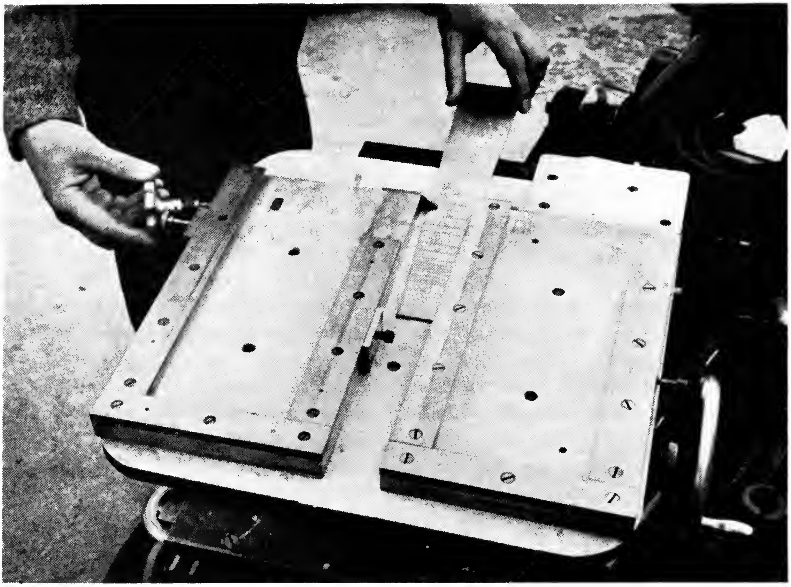


Fig. 9. Wedge used for adjustment of stereoangle.

Fig. 10. Universally jointed drive for adjustment of convergence angle and for swinging one camera aside for film inspection.

responsible for this development in England intend to push forward with the production of other films. But what of the entertainment world, based on Hollywood? Will three-dimensional films, which have so long remained just around the corner — like television not many years ago — finally step out and make the flat film as obsolete as the silent film?

This is obviously not a step to be taken lightly by the industry's leaders. It is their responsibility to protect and exploit the present investment in flat films, and above all the present roster of film stars, who might not weather the transition to a far less flattering form of presentation any more easily than the silent stars who had to find voices. Hollywood will have to decide, now or in the future, whether its box-office revenues are sufficiently menaced by the attractions of other kinds of entertainment to justify so radical and therefore risky a change. The studios will also have to bear in mind that television can add a third dimension more easily than can film, and that this step forward is likely to be taken as soon as the novelty of color begins to wear off.

Use of Glasses

If these arguments are beginning to recommend a change, the industry is undoubtedly deterred by a technical consideration on which I should like to say a few words, though it demands a paper in itself. Exhibitors are almost unanimously against all three-dimensional systems which demand the use of special viewing glasses, whether of the permanent or the throwaway kind, and their objections are entitled to the utmost respect. Under the rather special conditions of the Telecinema, we feel that this problem was virtually solved. The glasses, made by the Polaroid Corp., had extremely attractive frames resembling beach glasses, and a large filter area, so that the audience was perfectly at ease when wearing them. Distribution and collection, with the aid of specially partitioned boxes, was accomplished by the normal staff of usherettes in periods of less than two minutes. Losses were small and there were no complaints of discomfort.

There is, however, among the public and the press a tendency to regard any stereo system requiring glasses as in some sense "old-fashioned" — this in spite of the fact that Polaroid was invented only 15 years ago. The following points about this system are therefore worth noting. It is the only practical system in which there is a continuous transformation of the image with movements of the spectator — in other words, there are no nonstereoscopic or pseudoscopic viewing areas. (For modern movies, the anaglyph system can be disregarded.) Secondly, the image separation is extremely efficient; under good commercial conditions, there is a leakage of only about 0.15% of each image into the "wrong" eye. No lenticular system yet constructed approaches this efficiency. There is no deleterious effect of any kind on the definition of the image, so that in adding the third dimension other necessary image qualities are not sacrificed. Finally, the conversion of theaters is cheaply and simply carried out, and the special screen is just as effective with flat pictures. These points should, I think, be given greater weight in discussion, especially when it is considered what a large part of the population wears glasses, and does not object to putting on an extra pair on the beach or when driving a car.

None the less, if two equally perfect three-dimensional systems were devised, one requiring glasses and the other not, there would not be a moment's hesitation in picking the one to use. It is therefore worth considering some fundamental points about these "glass-less" systems. Firstly, the problem of image selection at the screen is very much more difficult than most inventors think; many able men are working today on

systems which have long ago been abandoned as profitless, or can be demonstrated as having no future. A few inventors — notably Ives, Kanolt, Noaillon and Gabor — have made fundamental contributions in the motion picture field during the last 20 years. The best treatment of this subject is the little-known group of patent specifications by Dennis Gabor,[4] whose research was carried out for the British Thomson-Houston Co. in England.

Two basic and very serious problems are made clear by this work. First, that the image-separating screen is of formidable complexity, and requires separate calculation and construction for each theater, according to the placement of its seats. Second, the resolving power of the lenticular structure gives an image definition much lower than would be acceptable for feature films, unless a manufacturing technique is assumed which is far ahead of what can be accomplished today. Thirdly, if the audience's heads are not to remain rigidly fixed, as in the Soviet system associated with Ivanow, a plurality of images must be provided for each eye, so that the eyes pass smoothly from one viewing zone to another and not into a position of blurred or pseudoscopic vision. The stills displayed in shop windows benefit from this plurality of images, because they give the passerby the illusion that he is walking past an object which he can see "in the round." But the moviegoer is essentially a stationary person, who is fully satisfied with the single view of the world which flat films have long given him. Hence the multiple views required by lenticular systems (to permit random head movements) are in a very real sense wasted. When it is considered that the storage capacity of 35mm film is already strained to the limit by the demands of high picture resolution and almost perfect color reproduction, it will be seen that the requirement of multiplying this capacity by a factor of 5 or 10 puts an impossible burden on the manufacturers of film.

Thus we have the contrast between a virtually perfect system, simple and inexpensive, which requires glasses; and systems dispensing with glasses which are today far from practical attainment, and which almost certainly would not repay the huge sums needed to develop them further. I believe that there is a way out of this dilemma, and that it is to be found by harnessing the science of electronics to solve some of the problems which are too refractory to be dealt with by optics.

For the Future

In all that has gone before, it has been assumed that the three-dimensional film meant the true binocular film, and not the flat film as projected on a giant screen, or spread out to the limits of vision, as in the Cinerama process. It is certainly true that a wide field of view enhances the feeling of being "in the scene," and is thus necessary in any attempt to give audiences a stronger sense of participation in the dramas of the screen. But I do not feel that there is any adequate substitute for true three-dimensional presentation; nor do I think that anyone who has worked extensively in this field and watched the reactions of audiences to these "films in space" would willingly revert to the flat films of today.

References

1. Norman McLaren (Appendix by Chester Beachell), "Stereographic animation — the synthesis of stereoscopic depth from flat drawings and art work," *Jour. SMPTE, 57:* 513–520, Dec. 1951.
2. J. T. Rule, "The geometry of stereoscopic projection," *J. Opt. Soc. Am., 31:* 325–334, Apr. 1941.
3. J. A. Norling, "Three-dimensional motion pictures," *Jour. SMPE, 33:* 612–634, Dec. 1939; J. A. Norling, "Progress in three-dimensional pictures," *ibid., 37:* 516–524, Nov. 1941.
4. British Patents, 541,751 and 541,753.

The Cash Customers

at the Festival of Britain Telecinema

By NORMAN JENKINS

This informal report describes the reaction of the audience to a most unusual programme of large-screen television, plus stereoscopic films accompanied by stereophonic sound.

THE SPONSORS, The British Film Institute, who have also commissioned the special equipment necessary, claim that the Telecinema is the first place in the world in which big-screen television, three-dimensional pictures and stereophonic sound can be seen on an equal footing with the established sound film.

The South Bank Exhibition of the Festival of Britain houses the Telecinema (officially the Telekinema), the title of which forces me to apologize for those of my countrymen responsible. For everything else all concerned deserve the highest praise mixed only with the modicum of criticism I feel it is necessary to record if only for the sake of objectivity.

The auditorium of the Telecinema is long and narrow, quite unlike the rather broad type of cinema to which we have been accustomed by building which took place in the thirties. There has, of course, been no building of cinemas after World War II.

The theatre walls cut square into the proscenium. This looks like nothing more than a modern picture frame which appears to be of material, five or six feet wide, splayed inward and neatly mitred at the corners. The flat faces are perforated and the substance looks rather like Celotex or other proprietary sound insulation sheeting. The holes are larger, however, and the material is continuous rather than in tile form.

The space between the proscenium and the screen proper is all screen. That is to say the whole proscenium opening is projection material of a specially curved metallic surface. The central portion is used for the picture and the peripheral space used for the projected surround.

The surround consists of a variable intensity of either white or coloured light. For television the surround is fixed value coming from a standard slide projector. For films the light

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A contribution which Norman Jenkins, 16 Rozel Rd., London S. W. 4, England, has made in response to a request by Society headquarters.

comes from a reflex arrangement which uses the picture itself, a few frames in advance, to modulate the light from the lamphouse of one projector.

Please note that the theatre walls cut into the proscenium and next comes the comparatively narrow surround, then the picture. Compared with the cross section of the theatre at that end the picture size is large.

In the space of a very few months equipment has been planned and manufactured and a cinema designed and built. In the same space of time the technique as well as the technics of large-screen television, stereo-cinema and stereophonics have been developed. All of these entirely variable and theoretical concepts have become actualities now earning money and indeed playing to completely full houses at every performance seven days a week.

Of the equipment itself, the design of the cinema and the technics generally, I propose to say very little. Raymond Spottiswoode, who is technical director of the project, has contributed a paper describing these in far greater detail than I obviously could do. [That paper, with illustrations, also appears in this issue of the *Journal*.] My interests are largely in detailing some of the reactions of the cash customer.

To know the reactions of the cash customer is, of course, vital to the establishment of any kind of commercial service of stereoscopy and stereophony in film entertainment and large-scale television. Whether or not I am best fitted to make the necessary observations I cannot say and for that reason the Society's Board of Editors has permitted me to make this purely personal contribution, deliberately personal, with but individual responsibility for the opinions expressed. I should further explain that I have no commercial interests whatever in cinema entertainment, but I have what I believe is a very wide technical knowledge and experience developed simultaneously with a most critical experience of cinema-going: in short, a film amateur, a professional cash customer.

First Visits

The first time I visited the Telecinema was before the exhibition opened officially. The attendant gave me a pair of stereo spectacles and showed me to a seat while part of a stereoscopic short subject, *The Distant Thames*, was being projected to an extremely small audience. I must say I regretted this experience, not only because it thrust me into a purely private showing but because I was not a part of a normal audience seeing a properly staged show.

Nevertheless, I was tremendously impressed by the cinema itself, the décor, the proscenium and even the attendants. I have seen less distinguished appearing and far less soignée programme sellers at charity shows. The chic clothes they wore and their air of friendliness were so exactly right as to baffle description.

For the part of *The Distant Thames* I saw, I had considerable difficulty in resolving sharp definition. I have since come to the conclusion that the fault was probably then in the equipment or its adjustment. Subsequent viewings have found the film sharp enough.

At the end and after the lights had gone up I was literally startled to hear a number of birds cawing and chirruping loudly in the course of flight around the auditorium. I knew, of course, it was reproduction and that was what I had come there for, but it was the first time I had become conscious of the stereophonic sounds. I had not noticed anything like it during the running of the film.

For some reason or another I was not invited to the press show. The national daily press greeted the programme with enthusiasm and was followed later by the technical press in similar terms. What few reports I saw in the technical papers were all favourable. I have

avoided reading all the reports heretofore because I did not wish to form any kind of bias before writing this report. The first regular showing I did attend was during the first two weeks. Unfortunately, the sound broke down, for a period entirely, and for the rest only a single track was used so there was no stereophony. In my later visits there was no interruption due to technical difficulties.

Large-Screen Television

This was the first time I had seen the large-screen television and although I had been discussing this with the cinema manager, Mr. Hazell, who had come to the South Bank from the Odeon at Penge where he had been accustomed to large-screen television, it was some time before I realized what I had been looking at.

The large-screen television programme has, from the opening day, commenced by showing the entry of the first cash customers. The performances are separate and whilst the house is filling the projector is running and showing a picture. This is picked up from the main entrance foyer, where not unduly bright lights suffice for the Marconi camera. Those in the auditorium see others entering and proceeding to the staircases.

When I entered the nearly full circle and saw a picture on the screen the thought did not register that it was a televised one. I was in just the mood of observation, rather than criticism. The picture was good, large and somewhat soft in tones of grey rather than black, but apart from that it looked rather like average to good 16mm. It was not until the commentator began speaking that I realized what it was and not then until he moved his head and body. When he did this the lines showed momentarily, sinking back into the picture on cessation of movement.

The number of lines used by Cinema-Television Ltd. is the same as that used for BBC transmissions. I am not a television user (speaking personally again, I do not see my money's worth in the possession and use of a receiver) and see programmes only occasionally. My memory of them, both prewar and recently, had led me to expect large-screen television to be something far more crude than this and much less acceptable. The best pictures I had previously seen were on a nine-inch tube and even the lines showed more than I, a film man, could accept. But this large-screen television is good by any standard.

Both on this and on subsequent visits I found that the audience would laugh at the least funny incidents. At the first large-screen television show I saw, I can well remember the commentator doing a live and impromptu interview with a gentleman from Mauritius. The latter was nervous and had a little trick of licking his lips. Every time his tongue came out the audience laughed and with repetition became hilarious. I wondered what the man himself must have thought if he had heard the laughter. After all, he was only in the foyer and his audience not more than a dozen feet from him.

The incident reminds me of the extraordinary feat of sound proofing which the architect and his technical advisers have done. Charing Cross railway bridge (Hungerford Bridge) is at no great distance from the outside of the cinema and the noise from a dozen or so rail tracks is practically continuous. Inside the cinema there is no detectable sound.

But to revert to the audience for television. At other shows I have noticed that the people coming in and behaving anything less than completely phlegmatically will raise a laugh, whilst the commentator can also raise a laugh for very little. I take this as part evidence of a rather specially conditioned audience. These folk have been waiting in line for an hour or more to get in.

Before that they have been tramping round a concrete floored exhibition getting more and more footsore. Almost any kind of well padded seat would have special attractions. But in addition the character of the exhibition must be added to the evaluation. This show is like nothing else they have seen and is an inspiring and uplifting experience. They have seen some remarkable things, presented in a most unusual way.

This audience is in a definable frame of mind as I see it: everyone is expecting something unusual. They have, after all, come to see stereo films and hear stereo sound, and to see large-screen television. They expect these things to be of a quality similar to those other strange and remarkable things they have seen. This audience is not likely to be critical, it is ready and eager to be amused, a "natural" for a comic. I think many showmen will know exactly what I am driving at.

The Picture Programme

Dodging backwards for a moment it is worth taking a look at the programme. It has been the same one for all these months and it is very likely that beyond minor adjustments it will continue without alteration until the close of the show.

First of all there is *Now Is the Time.* There is nothing quite like this in the average cinemagoer's experience. It is animated cartoon, but with the possible exception of short shorts advertising the usual soap or cigarettes, there is no point of contact. This film is, of course, stereoscopic and in colour and has the added unfamiliarity of synthetic sound — photographed patterns.

The next film is *Around Is Around.* This is another film with no point of contact with usual cinematic experience. Briefly, the stereo pairs of this film are produced by the traces of cathode-ray tubes, synthetically displaced and photographed in color. The sound tracks of this film are recorded in multiple and in depth and width — stereosound.

The next film is really typical of the average magazine reel. (I mean absolutely no disparagement; I know too well the compelling circumstances normally applying to newsreel magazine production.) *A Solid Explanation* was made in black-and-white by the Pathe Documentary Unit of Associated British-Pathe Ltd., and is a one-set background for a commentator somewhat heavy-handedly explaining that stereoscopy is a matter of to and from, as he does this and that, and as to the zoo animals he describes. The aquaria and outdoor zoo sequence that follows go to form the only familiar scenes of comparison.

The Distant Thames is a perfectly straightforward piece of photography of the river and as such should form a point of contact. Unfortunately for this contention almost all of the film is in motion. There is a very short sequence at Windsor Castle where the zoo film technique is merely duplicated in Technicolor.

It is, I think, well enough known to both technicians and film producers that a camera moving sideways across a subject, or better still around it in an arc, will produce an illusion of stereoscopy, even in a two-dimensional film. Paramount, I believe, tried (or succeeded, I just don't know) to patent this for a series of animated model-cum-cartoon films they produced in the thirties. Well, *The Distant Thames* confuses the issue by spending an estimated 98% of its footage in sideways or forward (very little) movement. I do submit that this is an unusual experience for cinemagoers. The sound accompaniment for *The Distant Thames* was post-recorded stereophonically in the Telecinema itself.

The concluding film in the programme is a cartoon in a most unusual technique. It consists of a static series of illustrations to the recitation of "John Gilpin." None of the illustrations moves. The pictures are in black-and-white only.

The camera moving across in certain sequences and quick cutting in others livens up the fast action demanded by the story. You know about John Gilpin, perhaps? He was a citizen of credit and renown. He went on horseback for a pic-nic to the Bell at Edmonton.... The sound accompaniment is nonstereophonic.

Details of the films and the credits are familiar to many, for the technical press has been generous in giving space to publicize this venture into the unknown. From those reports I have seen I must remark how little criticism, either informed or otherwise, has been offered: it has mostly been purely descriptive and noncommittal.

Audience Reaction

The reception given by the audiences present at those times when I have visited the cinema has been near enough the same as far as I can judge. The first film opens to an appreciative hush, following polite applause for the television commentator. The donning of the stereo spectacles causes a hum of excitement and anticipation, although there must have been many who remember the MGM prewar stereo films, when the more familiar red and green (and nonreturnable) cardboard viewers were used. The man behind me last week made a loud reference to the fact that this was nothing new.

The effect of depth in *Now Is the Time* is instant and clear cut. I do not suppose there is anyone in the whole audience, unless one-eyed, who could not appreciate this. The picture is brilliant and as well illuminated as any normal cinema screen. It is only 15 feet wide anyway and there are two 50-ampere arcs kept at a constant level, one for each of the overlapping pictures.

As the animated drawings moved forward, apparently out into the auditorium, there were always some gasps of surprise and laughter which, by the end of the programme when the swans of the Thames film did the same with their long necks, had sobered down considerably. Numerous children stretched out their hands to see if they could touch the images. Applause after each film, by the way, was generous to start with but faded away.

The musical accompaniment of *Now Is the Time* is so appropriate, synthetic as it is, that the novelty and to some extent eerie effect of the film is enhanced. This film and *Around Is Around* are so much in tune with the spirit of the exhibition of which the Telecinema is a part that I for one, when I first saw this programme, felt a thrill of new experience.

I wish that *Solid Explanation* formed no part of the programme and that *The Distant Thames* had perhaps been replaced with another, or had been placed at the commencement of the programme. I have been left with very mixed feelings: either this programme should have been, as it is represented as being, a true means of comparing stereoscopic films with the normal cinema, or it should have been so completely experimental that there was no point of comparison.

As it is, with the comparison that is made by *Solid Explanation* and *The Distant Thames*, completely realistic as is the one and quite beautiful as is the other, there is but a poor impression to be gained from the first and no comparison of value that can be made with the second. It is not as though *The Distant Thames* can be compared with any recognizable technique in travelogues or documentaries. This film relies on the natural beauty of the subject and two technical tricks, one forward motion and the other stereoscopy. Of the effect of stereo sound, please note later comment.

Of the effect on the audiences there is not much more that can be said factually. Of the impressions I have gained from listening to several performances — listening, that is, to comments in the locality of my own seat

and chatter from folk on the way out — and from discussions with others who have seen the programme either with me or at other times, I have gathered the following. Most folk are sufficiently impressed to speak of their experience as "wonderful" and regard the whole thing rather as a technical miracle. What they have to say to their friends intrigues sufficient numbers to keep a queue outside waiting up to a couple of hours for a performance — but I have yet to hear people saying "you *must* see the Telecinema" in the tone adopted to recommending a feature film of the quality of, say, *The Lavender Hill Mob*.

Incidentally, if you saw and liked *Kind Hearts and Coronets* you will know that Alec Guinness and the Ealing Studios comedies can be good. They excel themselves in *The Lavender Hill Mob*. It is not yet on general release and will certainly be passed on from one to another as a "wow." But I fear that the effect of stereoscopic films and stereosound does not even equal that of an unusually good feature film.

Audience reaction to the programme as far as films are concerned has been dealt with but this report would not be complete without some reference to the effect on the audience of the remainder of the technical effort. Although the architecture and equipment are not considered in detail in this paper, I do feel it necessary to explain the effect of the proscenium design in relation to the screen size and the system of projected surround, and also to mention the effect of the loud speaker placement and the effect of stereosound.

Modulated picture surround was tried out by British Thompson-Houston engineers when the Odeon Cinema in Leicester Square was first commissioned and this, the Telecinema, is the second attempt. I believe that neither experiment is conclusive. As far as the Telecinema is concerned, it is my personal opinion that the proportions of the screen end of the theatre, the screen size, the proscenium and the surround are by no means right.

But that depends upon the initial intention. If all concerned were of the opinion that stereoptics and stereophony would make the cinemagoer think he was in the picture and of it instead of merely being a privileged spectator, a dreamer of clear-cut dreams, then in my opinion such an idea is proved to have failed. The effect of the present design is very effectively to present a window, through which unusually beautiful effects of depth in recession may be observed and occasional effects of depth in protruding procession.

I am sure Mr. Spottiswoode, who is much more qualified than I am, can explain why this is so because the change in effect is so marked. In one case everything is *in* the theatre and in the other everything is so much smaller and seen *beyond* the window frame.

I have done much experimental work myself in projection with the object of creating the perfect illusion and have found to my own satisfaction (the personal aspect of these comments must not be lost sight of) that the best effect is obtained by aiming at a picture suspended in space, a picture materializing, as it were, in one's own home or in the theatre where there is no surround noticeable at all. It is a remarkable fact that the continent of Europe has not taken so much notice of the necessity for proscenium design as we have here in the United Kingdom. In France, Belgium and Holland I have noticed that the picture is usually far too big for both proscenium and theatre in just the same way as at the Telecinema.

I do not wish to make this an opportunity for airing my own theories, but I am not yet convinced one way or the other of the efficacy or necessity for a picture surround. In seeing superimposed subtitles on foreign films I have noticed, as others may also, that white lettering gains contrast where it appears on areas of picture that are not

necessarily black, or if they are on black then where the letters are near to areas of light tone — not necessarily, again, of completely white areas. That is not very well expressed, perhaps, but it is descriptive of a transitory effect and may strike a chord in those who have had similar experience.

Assessment of the Stereosound

Of the stereosound in the Telecinema I must say that from personal experience it is by no means as successful in illusion as the stereo picture. The latter is noticeable from any seat and from any angle. The depth in sound is effective from central seats only and best from the central seats in the circle. In side seats there is an occasionally noticeable roving sound.

On the occasion of one visit I had a downstairs seat on the left-hand gangway, about one quarter or less from the back wall. By dint of knowledge and conscious effort I could hear sounds coming from the rear and side, but only when I decided that I ought to be hearing them in that manner.

Subsequent visits and some thought given to the troubles I knew the recording people were experiencing have produced the opinion that it is the methods used as much as the natural circumstances which are responsible. For instance, in *The Distant Thames* bird noises are supposed to travel round the auditorium. They do, undoubtedly, but background music appears to have no direction, or else it comes from the screen end only. To me, there was auditory confusion. If at any one moment only one sound direction were used and a directional sequence were employed to make that sound travel, the illusion would succeed whatever the position of the hearer.

The only check employed was to question a neighbour on the downstairs gangway in deliberate non-clue language. I asked him "What did you think of the direction of the sound." He had no idea how, or reason for answering, to please and said "Why! from the front, I suppose." Both of us were within ten feet of one of the nearer rear speakers but he certainly hadn't noticed anything coming from it. And I had only by conscious effort. The point was confirmed by a friend a little further to the rear on the same occasion.

From the same seat I did notice that sounds following movement in depth certainly did so with considerable realism but I question whether it was better done or results were better than first-class recording and a normal single-channel system would produce.

Having made these remarks by way of criticism and for the record it would be wrong not to say that in summary there is here at the Telecinema a concrete example of very considerable and noteworthy achievement. Theoretical concepts have been brought to reality in a remarkable space of time and if some of them point to ways which should not be followed, then they may equally point to ways that must. Someone at some time had to make a start and it is with national pride that we here see that the British Film Institute has taken the lead.

The Telecinema is to stay. It has a site that no one is likely to covet and it is to be hoped that sufficient money has been taken at the door during the exhibition to finance more experiment. I am certain that when dialogue, for instance, is recorded and characters to left and right are heard to speak, as is usual, one at a time, then the effect of stereophony will be much more easily heard and understood than at present where unplaceable noises have to fight for their presence with overall background music.

I am looking forward with the keenest pleasure to seeing more and more programmes not only in the Telecinema (whose title I hope they will change but I fear they won't) but also in the

general run of cinemas. There is nothing in the equipment, either in the large-screen television or in the stereo systems to prevent this — there is only expense.

To the average cash customer I think the Telecinema was a passing novelty, and a glimpse into the future. To me, and I am sure to many other technicians, it has been a tremendously impressive experience and certainly a privileged occasion.

The professional reputations of those concerned have been very considerably enhanced by the universally favourable and successful reception given to the realization of their efforts. I would like permission to name them all.

Those Responsible

Architect, Dr. Wells Coates

Programme Producer and British Film Institute Representative for the Festival, John D. Ralph

Technical Director, Stereofilm Production, Raymond Spottiswoode

Supervisor of Television Production, Malcolm Baker-Smith

Cinema Manager, A. F. Hazell

Stereophonic Recording, Ken Cameron (By courtesy of the Crown Film Unit)

Stereo-Projection System, The British Thompson-Houston Co., Ltd.

Stereosound Recorders and Reproducers, The British Thompson-Houston Co., Ltd., and His Master's Voice

Large Screen Production Television System, Cinema-Television Ltd.

Optical-Magnetic Sound 16mm Projector

G. A. del VALLE and F. L. PUTZRATH

Heretofore, the task of recording sound on 16mm film has been a job for the engineer and the most aggressive amateur. With the advent of successful striping of 16mm film with magnetic coating, synchronized sound with picture is now a reality for a greater number of people. The instrument described in this paper has been designed to record, reproduce and erase magnetic sound track, as well as to reproduce photographic sound track of 16mm film.

EVER SINCE iron oxide coated tapes became an accepted medium for sound recording, the possibility of applying the same material to 16mm motion picture work has been very evident. Work in our laboratories at Camden for developing and designing equipment to handle this film has been going on for several years.

The problems of applying the narrow strips of magnetic material to 16mm acetate stock have not been simple, and this doubtless explains the relatively late appearance commercially of magnetic sound on 16mm film. Reeves Soundcraft Corp. made satisfactory film samples in the latter part of 1950. Magnetic stripe on 16mm and 8mm was earlier described and demonstrated by Marvin Camras.[1,2]

Presented on October 18, 1951, at the Society's Convention at Hollywood, Calif., by O. B. Gunby, for the authors, G. A. del Valle and F. L. Putzrath, Radio Corporation of America, Engineering Products Dept., RCA Victor Div., Camden 2, N.J.

The projector that we are about to describe is basically an RCA 400 Senior projector (Fig. 1) which has been modified to accept the component parts required for recording and reproducing magnetic sound track without altering, in any way, the characteristic simplicity of its threading.

This projector actually performs four functions: (1) It reproduces photographic sound track; (2) it erases and records magnetic sound track; (3) it reproduces magnetic sound track; (4) it can be used as a public address system. Any one of these four functions can be chosen by simply turning two knobs, one (Fig. 2) to select the amplifier operation desired, and one (Fig. 1) to select the type of sound track to be played. Recording level is checked by a glow-lamp indicator which is located on the upper portion of the amplifier panel.

For recording and reproducing magnetic track, a very small record-play

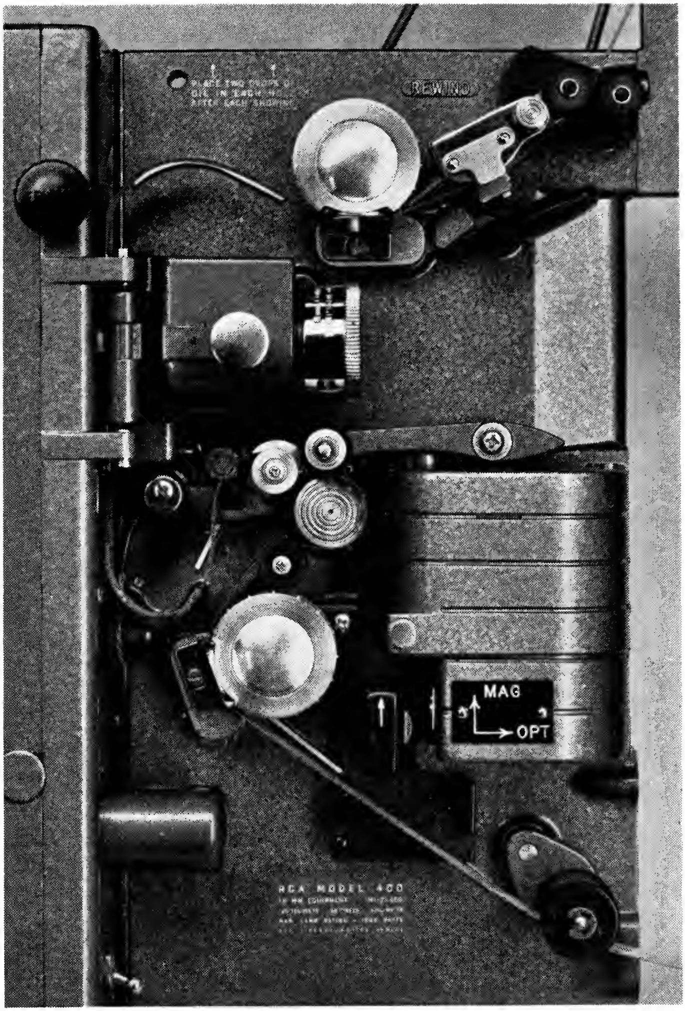


Fig. 1. RCA-400 magnetic projector showing location of erase head, and track-control switch.

combination head has been mounted inside of the sound drum, as shown in the partially disassembled view, Fig. 3. The erase head has been mounted just ahead of the upper sprocket, Fig. 1. The location of the record-play head inside the sound drum offers several advantages over any other location. The constancy of film motion is optimum at this point and the distance from sound to picture can be maintained exactly the same as that standardized for photographic and proposed for magnetic tracks.

Anyone familiar with the behavior of 16mm acetate stock can readily understandard the difficulties encountered in obtaining good physical contact be-

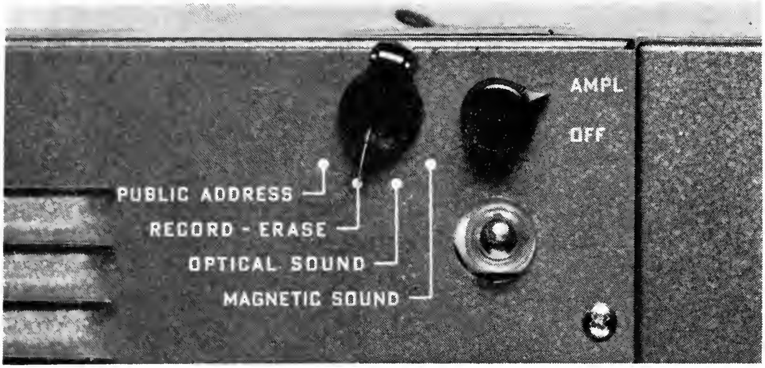


Fig. 2. Amplifier function selector switch. Signal level indicator is shown just below switch knob.

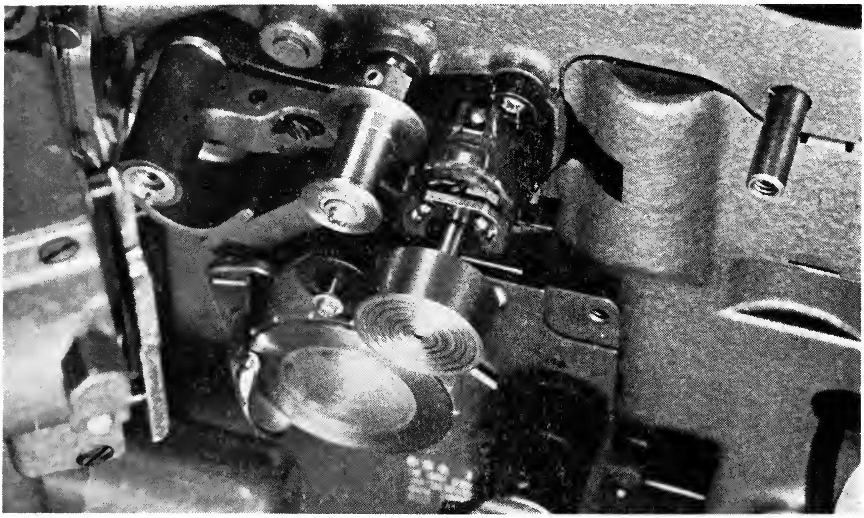


Fig. 3. Sound drum partially removed to show magnetic head assembly

tween the magnetic head and the track on a film that may be anything but flat. In the RCA 400 magnetic projector good physical contact has been obtained between film and head consistent with low head wear and low film deformation. The head is mounted on the free end of a hinged, spring-loaded arm which also automatically compensates for head wear.

In order to obtain maximum tracking of the head (Fig. 3) against the film, it was found necessary to provide four distinct adjustments for the record-play head: azimuth, lateral, pressure and bearing adjustments. For the purpose of adjusting the magnetic gap for azimuth, or perpendicularity in relation to direction of travel of the film, the magnetic head has been de-

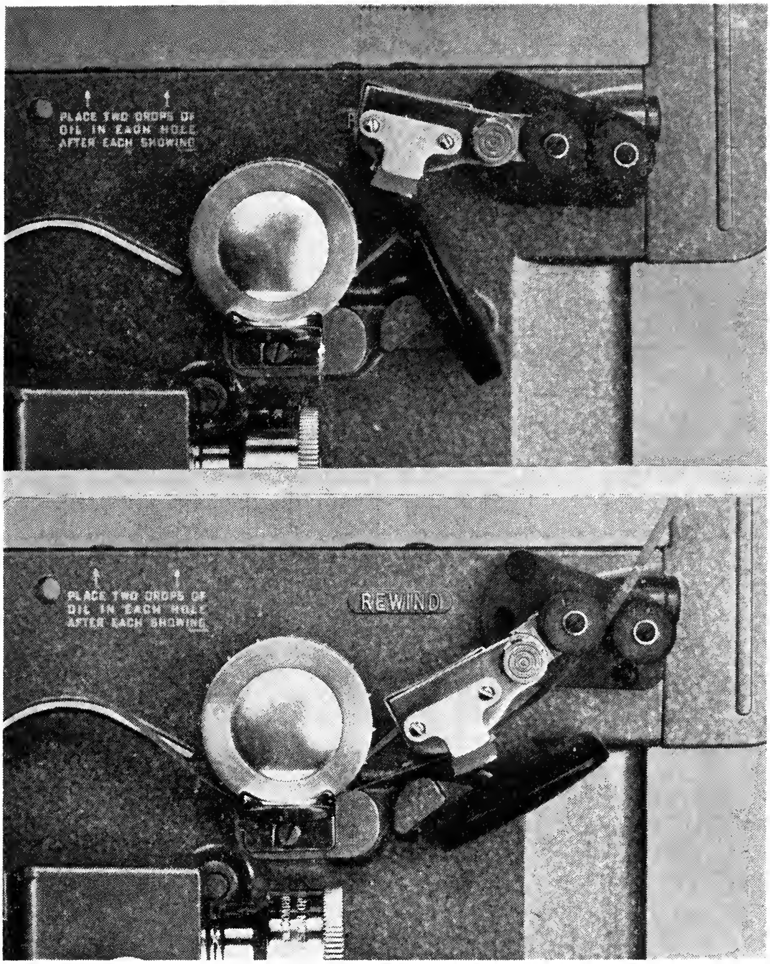


Fig. 4. Erase head and rewind lever.
Above — On "rewind" position. Below — On "Operate" position.

signed to fit a circular cavity in the arm, the center of which should lie in the exact center of the magnetic gap longitudinally and transversely. It has been found that this adjustment can be performed accurately with the aid of a high-power toolmaker's microscope.

For the purpose of centrally locating the magnetic sound track in relation to the width of the pole piece (or lateral location of film) the same adjustment is used as was originally provided for photographic sound track, i.e., axially moving the roller which guides the film into the sound drum. The photographic track is adjusted by means of a split threaded bushing located at the anchoring point of the exciter-lamp bracket.

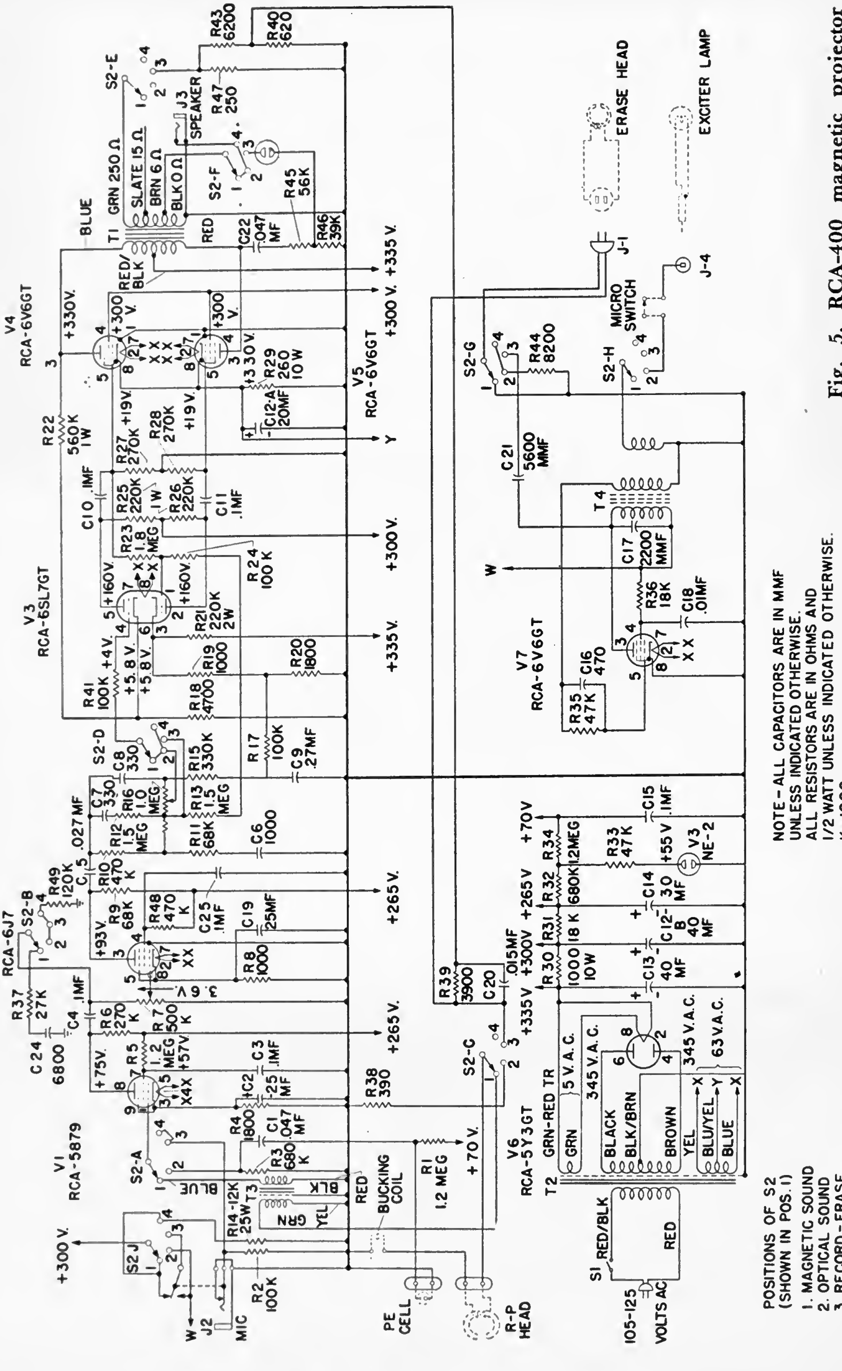


Fig. 5. RCA-400 magnetic projector schematic wiring diagram.

The amount of pressure between head and film is controlled by merely turning a set screw. A nylon insert, through which this setscrew passes, locks the screw in position.

The last adjustment of the magnetic head is to obtain the best possible alignment of the magnetic head film-bearing surface in relation to the curvature of the sound-drum periphery. This is obtained by rotating an eccentric bushing which is located at the fulcrum point of the arm supporting the magnetic head. This adjustment is performed by rotating the eccentric bushing until maximum output from a high-frequency recorded track is obtained.

The erase head has also been mounted on a hinged arm (Fig. 4) but for a different purpose. Perhaps one of the weaknesses of magnetically recorded sound is the possibility of unintentional erasure of the recorded signal. In the RCA 400, rewinding of film is accomplished by merely threading the tail end of the film into the upper reel, tripping the rewind lever, and starting the projector.

To render the projector as nearly foolproof as possible, interference was intentionally provided between the rewind lever and the erase head. In other words, upon completion of a recording, the erase head must be moved out of the way to permit the rewinding of the film. This automatically removes the erase head from the film-threading path. One can erase only when the erase head is deliberately pushed down into position and the film threaded through it. Besides this precaution, it is also necessary to turn the function-selector switch in the amplifier to the *Record-Erase* position and to insert a plug in the input jack. If any one of these last two operations is not performed, the erase head will not be energized. For efficient erasure of the recorded signal, it is also essential that good physical contact be maintained between the sound track and the magnetic gap. For this purpose, we have provided a small plastic shoe with very light pressure which holds the film directly against the magnetic gap of the erase head.

Two guide rollers (Fig. 4) have been provided ahead of the erase head. These rollers maintain the film at a constant angle as it enters the erase head independent of the reel diameter.

As mentioned before, the projector reproduces photographic track. This is accomplished by merely placing the selector switch (Fig. 1) in the *Optical Sound* position and the track selector on *Optical*. When the track-selector knob is moved to this position, a microswitch completes the circuit for the exciter lamp and at the same time the magnetic head is retracted to prevent it from making contact with the film. These two precautions not only make it mandatory to turn the track-selector knob to obtain exciter-lamp excitation, but also make it impossible to scratch the track as it passes over the magnetic head when reproducing photographic sound.

The amplifier described in this paper is somewhat similar to the one used in the 16mm Senior RCA 400 Projector. The original amplifier employs one pentode and two triode voltage amplifiers, one triode phase inverter, and push-pull pentodes in the output with an inherently stable feedback circuit. The input is taken from either a photoelectric tube or a microphone. The amplifier delivers 10 watts into a 6-, 15- or 250-ohm load. A volume control and a tone control (which tilts the frequency response about an 800-cycle center frequency) are provided. The polarizing potential for the phototube is regulated by means of a glow lamp. An rf oscillator supplies power to the exciter lamp.

The new amplifier model (Fig. 5) meets all the performance requirements of the standard projector and, in addition, has all the facilities necessary for

the recording, reproducing and erasing of sound on the magnetic-coated film. The modification of the amplifier has been accomplished mainly in two steps:

(1) The gain of the amplifier proper has been increased by substituting a pentode for the triode voltage amplifier, resulting in the following tube complement:

1 — 5879 voltage amplifier,
1 — 6J7 voltage amplifier,
1 — 6SL7GT voltage amplifier, phase inverter,
3 — 6V6GT push-pull output stage, rf oscillator,
1 — 5Y3GT rectifier, and
2 — NE-2 voltage regulator, recording level indicator.

(2) A 9-pole, 4-position switch has been used to permit the selection of any one of the previously mentioned projector functions.

For the reproduction of magnetic sound (S2 in position 1) the record-play head is connected to the primary of the input transformer, the secondary winding of which is connected to the grid of the first voltage amplifier. The turns-ratio of this transformer was chosen so that the resonance between the inductance of the record-play head and the distributed capacity of the transformer secondary falls slightly beyond the useful audio range of the system. A special load is connected to the plate circuit of the first voltage amplifier giving the required low-frequency compensation. The signal then goes through the regular amplifier path, including the pentode and triode amplifiers with their volume and tone controls, the phase inverter, and the push-pull output stage. The amplifier load is the speaker. To avoid possible erasure of the magnetic film no plate power is applied to the oscillator tube. However, a dummy load maintains a constant load on the power supply.

For the recording of sound on the magnetic film (S2 in position 3) the grid of the input is connected to the microphone. The signal follows the regular amplifier path except that the tone control circuit is disconnected, insuring a "flat" recording characteristic. The speaker load is disconnected to avoid accidental acoustic feedback. In its place, a dummy load is connected across a 250-ohm output winding. A suitable voltage divider across this load feeds the record-play head through the compensation network (R-39 and C-20). In order to avoid accidental erasure the oscillator receives plate power only while a microphone plug is inserted. The oscillator load is connected from the primary side of the transformer and is formed by a series-parallel combination of the erase head, the record-play head, C-20, R-39 and R-40. Thus, the mixing of the audio and biasing currents for the record-play head occurs between the head and the compensating network. The switch section which was used to disconnect the speaker load now completes the circuit of the recording-level indicator, an NE-2 tube. The resistive network associated with this indicator is adjusted so that the indicator flashes at a signal level slightly below the overload point of the film.

Several problems were encountered in the design, layout, and location of the amplifier and its associated components along the film path. In order to avoid distortion and high hiss-level, it is imperative that no residual magnetism be left in the record-play head. Thus, means must be provided to decrease the bias current in this head to a small value before it is entirely removed. In this model a step-by-step bias attenuation is accomplished automatically when the amplifier is switched from the magnetic recording position. In particular, S2-J (being a shorting-type switch) temporarily parallels the oscillator tube and the dummy load that otherwise takes its place. Thus, a reduction in B-supply voltage is

effected, decreasing the recording-head current. S2-G and S2-H (also of the shorting type) temporarily load the oscillator tank primary and recording windings with R-44 and the exciter lamp respectively also effecting a decrease in bias current. Similarly S2-C shunts the record-play head with R-38. Since these means of reducing the bias current in the record-play head will occur successively in some random sequence, the head will be left in an essentially de-magnetized state at the time when the biasing current is completely removed. If the microphone jack is removed while S2 is in the *Record-Erase* position, the capacities associated with the oscillator will permit exponential decay of the amplitude of oscillation.

Because the amplifier is used for four different functions, careful layout of the wiring and switching is required. Since one head is used for recording as well as playback, connections between the amplifier output and input are required. To gain some measure of isolation in this circuit the available intermediate switching contacts are essentially grounded. There is also a tendency for the oscillator signals to be electrostatically coupled into the amplifier proper. Careful wiring again limits these signals to levels sufficiently low to avoid adverse effects on the amplifier operation.

The external magnetic fields of the power transformer, the motor and the projection lamp are of sufficient magnitude to introduce hum into the circuit components and wiring. The effect of these hum generators is somewhat reduced by adjusting their physical location as far as feasible. Thus, the motor and power transformer are located as far away as possible from the record-play head. The motor can be rotated axially and the transformer, being supported in a special mounting, can be physically adjusted to give minimum hum interference.

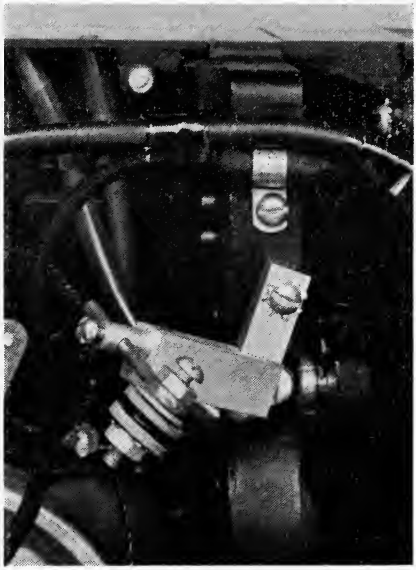


Fig. 6. Hum-canceling coil located on the main frame of the projector.

It is also possible to minimize the hum pickup at the disturbed points. Thus, a well-shielded input transformer is used and rotated for minimum hum pickup. All the low-level leads are tightly twisted and the layout of the switch wafers made to minimize open loops in the wiring. Ground loops are completely eliminated.

The residual hum is eliminated by the use of a hum-bucking coil (Fig. 6) in series with the record-play head. It was not possible to obtain a single minimum hum-bucking coil adjustment for the two conditions of projection lamp "on" and "off." However, a compromise coil position was found which gives satisfactory overall performance.

The performance of the electrical system may be summarized as follows: Since the output stage of the amplifier remains essentially unchanged, the power output rating is identical to that of the original amplifier. Also, overall charac-

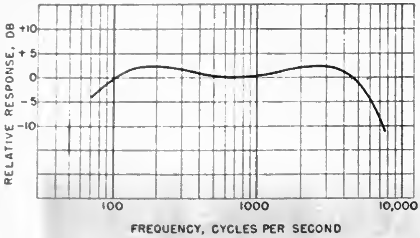


Fig. 7. Overall frequency response of the system for a signal recorded and played back.

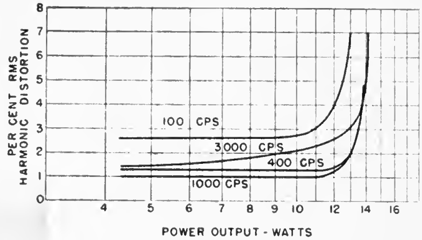


Fig. 8. Distortion curve of the amplifier.

teristics of the amplifier for optical playback and public address remain unchanged. During magnetic recording, it is possible to have 35-db attenuation in the volume control before the input stage overloads. The amplifier output networks are adjusted so that the amplifier distortion will always be small compared to that of the recorded signal. Thus, optimum signal-to-noise ratio is obtained during recording. With modulated film, the amplifier has approximately 15-db gain reserve during playback. Under these conditions, the signal-to-noise ratio is 50 db with the tone-control in the flat position. The overall frequency response (Fig. 7) of the system, for a signal recorded and played back on this projector, is flat within 5 db from 100 to 6000 cycles/sec.

The general specifications of the RCA 400 magnetic projector are given in Figs. 7 and 8 and in Table I. Figure 9 shows the complete unit.

The versatility of application of the basic development becomes apparent

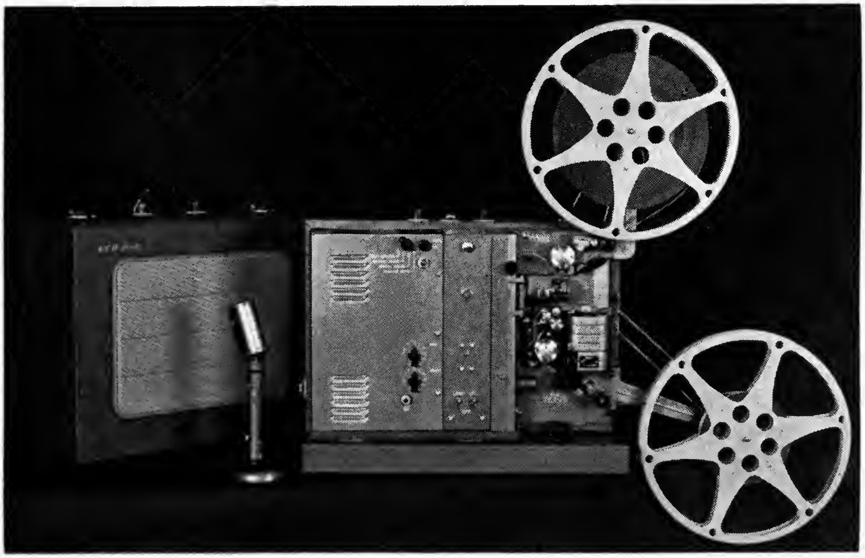


Fig. 9. The RCA-400 magnetic projector ready for operation.

Table I. Specifications of the RCA 400.

Amplifier power output (400 cycles, 5% distortion)	10 w	
Film speed (24 frames/sec)	7.2 in.	
Frequency response (magnetic)	100–7200 cycles	
Signal-to-noise ratio (magnetic)	50 db	
Input impedance	100,000 ohms	
Record-play head:		
Gap length	0.0005 in.	
Pole piece width	0.084 in.	
Inductance (1000 cycles)	3.4 mh	
Erase head:		
Gap length (double)	0.007 in.	
Pole piece width	0.125 in.	
Inductance (1000 cycles)	14.0 mh	
Exciter lamp frequency	50,000 cycles	
Cost of applying magnetic track to film (tentative)	3½ cents/ft	
	Projector	*Speaker*
Weight	45 lb	26 lb
Dimensions:		
Length	20½ in.	19⅝ in.
Width	9 in.	9 in.
Height	15 in.	15⅝ in.

with the enumeration of some of its potentialities. One particular advantage of magnetic recording is that the sound track is independent of the film emulsion or developing processes. The sound itself can be added either before or after the film has been developed for picture, resulting in great flexibility of editing. Lip synchronization can be obtained in a few trials.

Besides the conventional method of recording sound on a standard 100-mil track, some variations have been tested which present decided advantages for certain applications. For example, half of the width of an optically recorded track can be coated with iron oxide material. Although the output of both tracks is cut by 50% and their signal-to-noise ratio decreased, great practical advantages can be realized. For instance, the tremendous wealth of knowledge that has been accumulated in this country in instructional 16mm films can be released immediately to our friends overseas. They in turn can make their own translations and recordings at a very nominal cost per print. This is but one of the many possible applications of a 50/50 track.

Another variation that has been tried with success is the double-film system. This idea, it is believed, is the one for which the amateur has really been waiting. It consists simply of running through the projector two films, one being the old double-perforated film containing the picture, the other being a clear film carrying the magnetic track. This system offers all the desirable characteristics of a standard track, though a given reel size will accommodate only one-half the usual film length. This, of course, is insignificant considering the complicated arrangements that the more aggressive amateur is using today.

Another system which may have practical possibilities is that of edge-coating the old, double-perforated film. Though this method would be somewhat simpler to use than the one described above, it presents three disadvantages: (1) High amplitude variations are present in the recorded signal due to the proximity of the sound track to the sprocket holes. (2) The limited track width will result in an only moderate signal-to-noise ratio. (3) A specially positioned head would have to be provided for on the projector.

The cost of producing sound on 16mm film with this multi-use equipment has been estimated to be about one-third of the cost of achieving comparable results photographically. In addition, film waste due to recording errors is eliminated. Thus, small commercial studios, schools and colleges, sales and advertising organizations, governmental agencies, training specialists in medical, military, industrial, religious and law enforcement fields and especially the

amateur movie makers and photographers will benefit greatly by this development. To such users this new recorder-projector means high-quality sound, greater flexibility, and greater operating convenience with savings in time, film and processing costs.

References

1. Marvin Camras, "Magnetic sound for motion pictures," *Jour. SMPE, 48:* 14–28, Jan. 1947.
2. Marvin Camras, "Magnetic sound for 8-mm projection," *Jour. SMPE, 49:* 348–356, Oct. 1947.

Discussion

Loren L. Ryder: In the interest of standardization with respect to frequency characteristics, I wonder if you are in a position to make available the frequency characteristics of this recorder-reproducer at this time. It's quite possible that the work that you have done may set a pattern which should be followed. Further, it may be to the advantage of all if at an early date there is a semblance at least of standardization so that the product to be reproduced on your equipment or handled with other equipment might be interchangeable. Is that information available?

O. B. Gunby: Since the authors of this paper aren't here and detailed information on the frequency characteristic is not available in Hollywood at the present time, your question will have to be referred to them. However, I have a slide here that shows the frequency response used in making this demonstration film.

Lloyd Goldsmith: Again I'm speaking as chairman of the Sound Committee for the Society and I'd like to report that at our Tuesday morning meeting it was brought out that our Subcommittee on Magnetic Recording is attempting to standardize, or at least act as a clearing house, for information on the frequency response and the pre- and postequalization in these magnetic recorder-reproducer projectors for the benefit of all of the manufacturers. Accordingly, Glenn Dimmick has already circulated this information to the Subcommittee with respect to the RCA projector and I will be very glad to make it available to Mr. Ryder. Also, Ampro has indicated their division of pre- and postequalization, and I'm sure that before very long there will be agreement on recording-reproducing characteristics to allow complete interchange of magnetic film made on this type of projector.

Mr. Gunby: The slide is now ready for presentation. You will notice that it gives only the overall frequency response. It probably doesn't completely answer Mr. Ryder's question, but the information referred to by Mr. Goldsmith and which can be obtained from the Subcommittee on Magnetic Recording will likely provide the additional data requested.

Twin-Drum Film-Drive Filter System for Magnetic Recorder-Reproducer

By CARL E. HITTLE

Use of two drums in tight-loop type of film-drive filter system solves the problem of film support in magnetic recorder-reproducer utilizing two separate magnetic head assemblies. Performance of filter system is analyzed.

Many valuable contributions have been made to the art of sound recording by the design of film-drive mechanisms and a wealth of engineering principles covering these endeavors can be found in literature.[1] It might be considered, however, that many of the film-drive mechanisms described in the references were designed for specific applications using photographic film as the recording medium, and were not particularly suited for the magnetic type of medium. The theory of recording with the latter has established certain requirements for the film-drive mechanisms. These were met only with some degree of compromise with many of the other photographic-type drives employed in what might be referred to as the interim period for the acceptance of magnetic recording by the motion picture industry. Magnetic recording, having proven to be a useful tool, has dictated the need for a more comprehensive design of the overall equipment as well as of the system components. The purpose of this paper therefore is to describe a film-drive mechanism especially designed for magnetic recording and one which makes use of the many advantages attributed to the magnetic medium.

Features of the film-drive mechanism especially designed for magnetic recording may be more fully appreciated when illustrated against a background of those of the basically photographic types which were converted for use of magnetic film.

The conversion of a photographic-type recorder to magnetic is shown schematically in Fig. 1. In this instance, the photographic-type sound drum was foreshortened so that the portion of the magnetic film from the sound track location to the nearest outside edge of the magnetic film would extend beyond the drum much in the same fashion as would be required for converting to photographic sound reproducing. The single magnetic head was mounted so that the recording gap portion of the head would contact the coated surface of the magnetic film at the required location. The film-drive filter system of this recorder was a tight-loop system utilizing a magnetic drive

Presented on October 18, 1951, at the Society's Convention at Hollywood, by Carl E. Hittle, Radio Corporation of America, Engineering Products Dept., RCA Victor Div., 1560 N. Vine St., Hollywood 28, Calif.

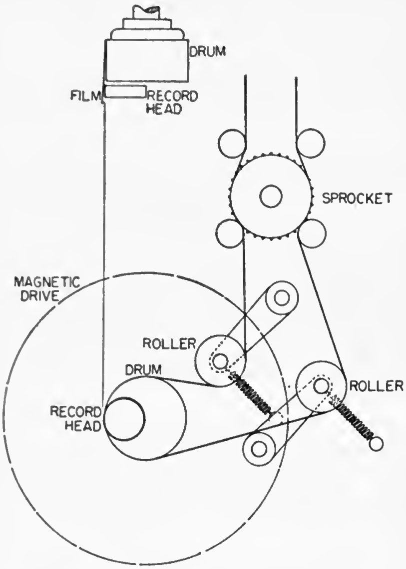


Fig. 1. Recorder having single magnetic head in drum.

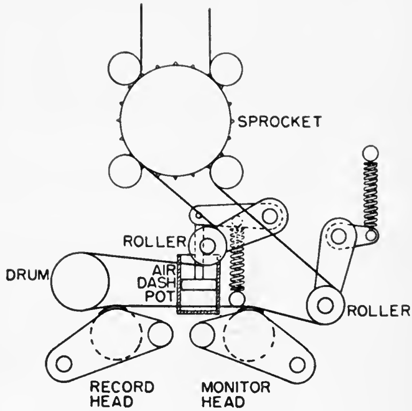


Fig. 2. Recorder having two retractable magnetic heads external from drum.

for the sound drum as described by Collins.[1]

As may be observed from Fig. 1 since the coated surface of the film was toward the inside of the film loop between sprocket and drum, space limitations permitted the mounting of only the one magnetic head shown at the drum. In this particular adaptation the one head was used for recording the sound track and later for reproducing with no facilities available for monitoring the recorded track at the time of recording.

When used for photographic recording prior to the conversion, this equipment at least equalled any other commercially available equipment in providing flutter-free film motion. The quality of film motion, when used for magnetic recording, was for practical purposes the equivalent of that when used as a photographic recorder. However, experience with the equipment as a magnetic recorder indicated the need of a more desirable location for the magnetic head since head wear tended to be uneven due to difference in pressure between film and head across the width of the head. The partial view in Fig. 1 shows in exaggerated form the position the film tends to assume with respect to the head and drum. Necessarily, the head at the magnetic-gap section must protrude slightly beyond the film supporting surface of the drum to provide the desired contact pressure between film and head. Unit area pressure tends to be relatively high at the edge of the head adjacent to the drum and to diminish as the opposite edge is approached. This tendency may be reduced to some extent initially by a slight rotation of the head.

A second illustration of a basically photographic type of recorder modified for use of magnetic film is shown schematically in Fig. 2. The film-pulled drum type, tight-loop filter system with damping applied by means of a dashpot connected to one sprung roller arm was retained since it too provided excellent film motion. In this instance (as well as in the remainder of the systems to be described) the film threading was such that the coated surface faced to the outside of the film loop between sprocket and drum. With only a slight change in the film path,

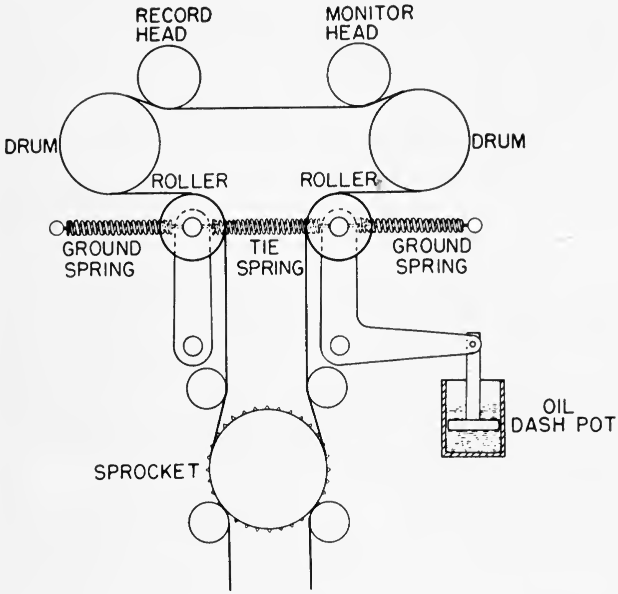


Fig. 3. Twin-drum recorder with drums in horizontal plane, single film sprocket.

space was made available for mounting both a record head and a monitor head. Since film motion tends to be of best quality at the sound drum or immediately following the drum with reference to direction of film travel, the record head was mounted adjacent to the drum on the film take-up side with the monitor head mounted as closely following as facilities would permit. The two head mountings were so designed that by actuation of detent pins the magnetic heads could be rotatably retracted from film contact position to eliminate possibility of abrasive damage to the film emulsion from head contact when using the equipment for photographic recording. This permitted almost immediate change-over from one recording method to the other.

One application of this equipment has been in television studios where double-film systems are used for making kinescope recordings of television programs. Operational economies are realizable due to the versatility of operation of this type of equipment. The purchase and use of such equipment becomes a money saving investment for television studios and others concerned with high-quality sound recording since either photographic or magnetic medium may be used for the original recording with magnetic recording available for making protection "takes" when two of these units are available.

Sound quality attainable with such equipment is at least as good with magnetic film as with photographic film. Reproduction using the record head is superior to that using the monitor head principally because of the better film motion obtainable at the record-head location. For this reason, the equipment is provided with switching facilities to permit the record head to function as a "playback" or reproducing head when best quality reproduction is desired.

Representative of the different approach used in designing a film-drive mechanism specifically for magnetic recording and reproducing is the mechanism shown schematically in Fig. 3. Since freedom of design permitted, an addition was made to the basic film-

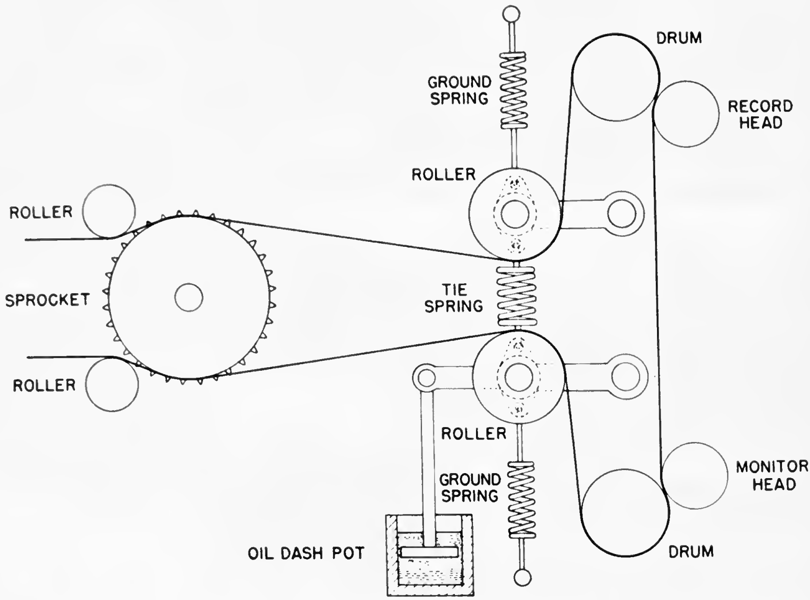


Fig. 4. Twin-drum recorder with drums in vertical plane, one film sprocket.

drive mechanism described in the last illustration given. This addition, made to provide film motion at the monitor head as nearly equal to that at the record head as possible, was a second impedance drum. The geometry of the film path, considering for the moment just the film sprocket and the two impedance drums, is basically an equilateral triangle in shape with the sprocket at the apex.

A sprung roller added to each of the two equal sides of the basic triangle serves two purposes. Each serves to alter the film path in such a manner as to increase the film wrap about its adjacent drum to the degree desired for film-pulled drum operation. The two sprung roller arm assemblies with associated tie spring are also essential elements in the twin-drum film-drive filter system. The relatively light sprung roller arms tend to absorb any disturbances introduced into the film motion through the film-drive mechanism. This results from the fact that the film is held in tight contact with the rotating drum surface and the much greater inertia effects of the rotating flywheel mass of the impedance drums make these elements relatively insensitive to such film motion disturbances. Damping of any tendencies of the sprung roller arms and the drums to oscillate is provided by the oil-type dashpot which is linked mechanically to one of the sprung arms. The oil used in the dashpot is a selected grade of temperature-stable silicone.

Film tensioning is furnished through the force exerted by the tie or center spring connected to the two sprung or tensioning arms when the film is threaded properly in the film path shown. Ground springs shown in the illustration are used principally for mechanical purposes and have little effect as functional members of the filter system. Without the ground springs, the sprung roller arms tend to rotate to one or the other extremity of their arc of travel, depending on direction of film motion.

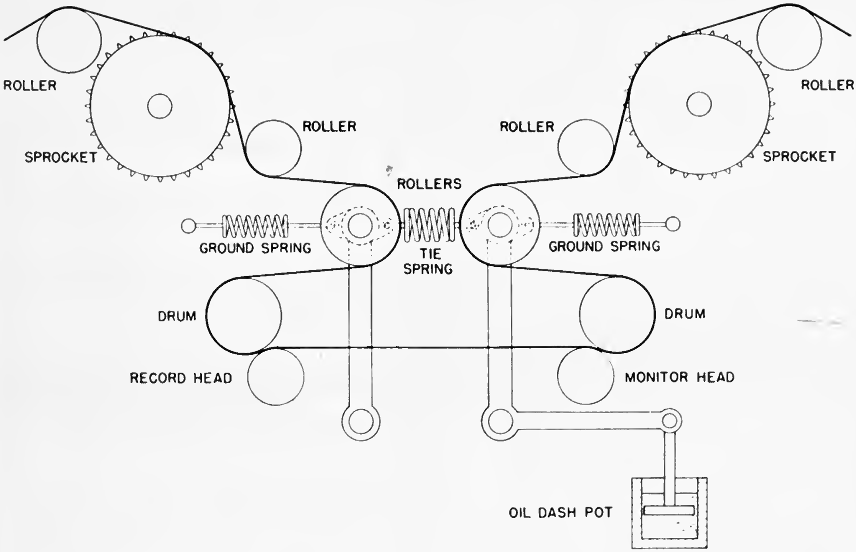


Fig. 5. Twin-drum recorder with drums in horizontal plane, two film sprockets.

Performance has justified the departure from the usual photographic-type film path to that which has just been described utilizing the two impedance drums. Flutter content of a recording reproduced by the record head is less than 0.1% rms total with less than 0.05% rms being 96-cycle flutter.[2] Flutter content using the monitor head for reproducing is less than 0.15% rms total with less than 0.05% rms being 96-cycle flutter.

It might be well at this point to mention two features relative to the use of the twin-drum assemblies. From outside our organization has come the suggestion that the inertia effect of the two impedance drums would have to differ by appreciable amounts to permit satisfactory performance free of beat-frequency disturbances from the two drums having equal size and weight. Our experience indicates through the consistent low flutter performance obtained that drum assemblies of equal inertia effect are satisfactory in the filter system which we are now using. The second feature relates to the position of the magnetic head with respect to drum to provide optimum film motion performance. Tests were made to determine if head position had the same relative effect on observed flutter as compared with that of single-drum magnetic recorders. These tests showed that head location with respect to drum along the path of the tensioned film between the two drums had no bearing on the quality of film motion. Since a latitude of choice of head location existed, locations for the record and monitor heads were chosen which permitted maximum useful head life to be obtained with the original factory head setting. These locations also provided protection for the heads at their most critical section, the film contact area at the magnetic gap, due to the close proximity of this area to the drum.

The mechanism shown in Fig. 4 is the basic mechanism of Fig. 3 rotated 90° with the dashpot appropriately relocated and is intended primarily for standard relay cabinet rack mounting

as part of a permanent magnetic recording system in studios. Equipments produced to date using the physical arrangement of components as shown have been of the triple-track type, as described by Singer and Pettus.[3] (It is equally adaptable for single-track magnetic equipments.) Quality of film motion even though six magnetic heads are in contact with the film simultaneously is equally as good as with the single-track equipment represented by Fig. 3.

Further illustration of the way in which the basic design of the twin-drum film-drive filter system has been adapted to meet varying space needs is shown in Fig. 5. In this instance, design requirements of compactness without sacrifice of quality of performance had to be met. Use of the second sprocket facilitated the attainment of both size and weight reduction. As may be seen by comparing Fig. 5 and Fig. 3, the filter system is essentially the same in the two illustrations. Film motion using the mechanism shown in Fig. 5 has proven to be equally as good as that described for the mechanisms of Figs. 3 and 4. Equipment utilizing the film-drive mechanism shown in Fig. 5 is described in the paper by Singer and Ward immediately following in this *Journal*.

The drum shaft assembly, sprung or tension roller assembly, and sprocket assembly of the twin-drum film-drive filter system remain essentially unchanged throughout the variations of the system previously described. The same basic filter system is used on 35mm, $17\frac{1}{2}$mm and 16mm equipments.

Field performance has furnished proof of the soundness of design of the twin-drum film-drive filter system, adequate solution of the problem of film support in the critical region of the magnetic head, and the advantageous choice of magnetic head locations.

References

1. M. E. Collins, "A deluxe film recording machine," *Jour. SMPE, 48:* 148–156, Feb. 1947; "Lightweight recorders for 35- and 16-mm film," *ibid., 49:* 415–424, Nov. 1947.
2. Proposed American Standard, Z57.1/68, Method for Determining Flutter Content of Sound Recorders and Reproducers, American Standards Assn., 70 E. 45 St., New York City.
3. Kurt Singer and J. L. Pettus, "A building-block approach to magnetic recording equipment design," scheduled for publication soon in the *Journal.*

Discussion

D. J. White: The thing that I found most interesting about this discussion of the dual drum filter mechanism was the reference that the speaker made to the "outside" sources who had called the attention of the industry to the fact that different inertias and different masses in the two inertia wheels make a definite and distinct difference in the characteristics of motion. As the originators of the dual flywheel motion path, we at Magnagram feel that we are somewhat qualified to make the statement that our experience has proved there is definitely a difference when the proper ratio between the two inertia wheels is achieved.

The first machine, which we introduced in May of 1948 to the Society's 63rd Semiannual Convention, employed dual inertia wheels of the character just described by the Speaker. Since that time, we've conducted numerous experiments and we have determined conclusively that we can reduce overall low-frequency modulation by making calculated changes in the mass and inertia of the two flywheels. For your information we refer to this as "Synkinetic" motion.

Carl E. Hittle: As mentioned during the reading of the paper, we can speak only from the experience which we have had with our type of system and I can only reiterate the fact that, in the relatively few years that we have been playing with this type of equipment, we have not encountered any difficulty due to the fact that our flywheels are of equal mass.

A Technical Solution of Magnetic Recording Cost Reduction

By KURT SINGER and H. CONNELL WARD

This new portable magnetic recording channel, designed primarily for 17½ mm film provides high-quality operation and all of the needed facilities for production recording. By operating at 45 fpm a considerable economy in film cost is realized and the size and weight of the recorder are reduced. The recorder is also adaptable for 16mm or 35mm film. A new amplifier system utilizing miniature tubes and small components is provided as part of the equipment.

On May 18, 1948, the first studio-type magnetic recording channel was described at this Society's Convention at Santa Monica, Calif.[1]; and, on October 27 of the same year the first portable magnetic recording equipment was presented at the Society's Convention at Washington, D.C.[2] Both of them used perforated 35mm magnetic film. Their demonstrations gave convincing proof that synchronous magnetic recording was a useful tool in the production of sound motion pictures.

These equipments were produced by the addition of the magnetic recording elements to existing photographic recording facilities, and, in some cases, the modified equipments were capable of using both photographic and magnetic film as the recording media. With a number of modified channels in service, information was obtained concerning the features and facilities that should be included in an equipment designed for magnetic recording only. The first of these was the PM-62 portable system. Shortly afterwards, the PM-63 and PM-66 rack-type arrangements were made for triple-track and single-track recording. These are described in detail in a paper entitled, "A Building-Block Approach to Magnetic Recording Equipment Design" by Kurt Singer and J. L. Pettus (to be published soon in the *Journal*).

Despite the accomplishments of these channels, many have felt that the anticipated saving was not sufficient to warrant converting to magnetic recording. There has also been the need for smaller, lighter-weight magnetic recording facilities capable of recording continuously a 30-min program for television applications. By previous standards, it would

Presented on October 18, 1951, at the Society's Convention at Hollywood, Calif., by Kurt Singer and H. Connell Ward, Radio Corporation of America, RCA Victor Div., Engineering Products Dept., 1560 N. Vine St., Hollywood 28, Calif.

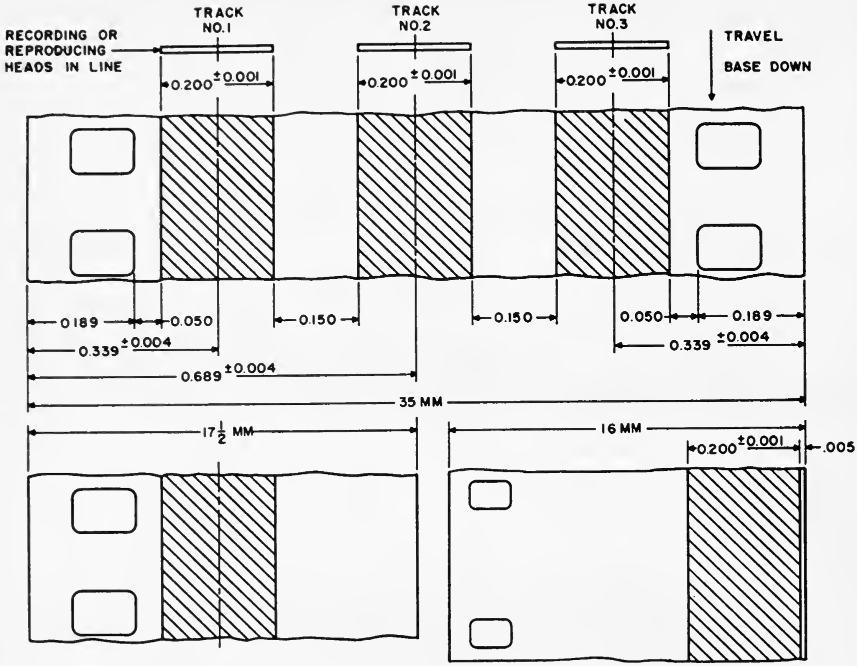


Fig. 1. Proposed magnetic film track standards for 35mm, 17½mm and 16mm.

be necessary for the recorder to use 3000-ft film reels for television and 1000-ft reels for location purposes. From additional investigations grew the idea of split 35mm film operating at "split" 35mm speed or 45 fpm for all original recording. The use of split 35mm film had already gained acceptance as evidenced by the 17½mm magnetic track location proposed by the Motion Picture Research Council[3] and later appearing as a proposed American standard.[4] Tests showed that 45 fpm provided a reasonable reserve in frequency range over that normally used in sound motion picture production and the ratio between this new speed and the standard speed for release film was made very simple. By splitting a 1000-ft roll of 35mm film which has a recording time of approximately 11 min at 90 fpm into two rolls and cutting it into 500-ft lengths, we have 44 min of recording time at 45 fpm. This automatically gives a film cost saving of 75% and approximately the same amount of saving in film storage space. In addition, the reduction in the initial film capacity represented a considerable reduction of recorder weight and volume.

As companion unit for this new magnetic recorder, a new amplifier system capable of being operated from either of two types of power supplies has been designed.

The above reviews briefly the steps leading up to the RCA PM-64 Portable Magnetic Recording Equipment which will be described in detail below.

Equipment Features and Adaptations

Many combinations of film width and speeds, motor systems and power supplies are available. For 35mm and 17½ mm width, recording speeds of 90 fpm or 45 fpm are available. For 16mm, a speed of 36 fpm is employed. Any of the

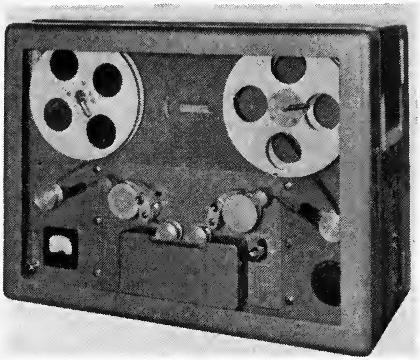


Fig. 2. PR-42 Portable Magnetic Recorder, $17\frac{1}{2}$mm equipped with 500-ft reels.

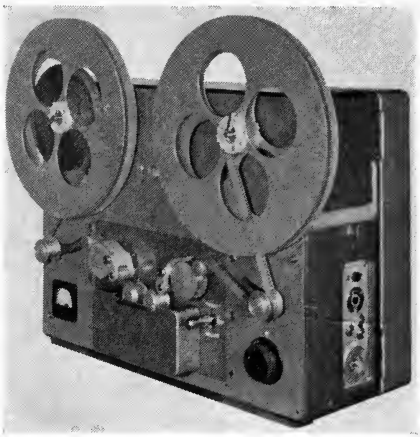


Fig. 3. PR-42 Portable Magnetic Recorder, $17\frac{1}{2}$mm equipped with 1500-ft reels, covers removed.

commonly used motor systems may be used with any combination of film width and speed.

This equipment adheres to the proposed American standard for track locations (Fig. 1).

The associated audio amplifiers meet the established studio requirements for high-grade recording systems. High-level mixing is provided for two microphones with four steps of dialogue equalization. The mixer may use either direct or magnetic monitoring and facilities are available for him to communicate with the recordist or boom man. The system may be operated from a-c mains or storage batteries.

Recorder Structure

The recorder as seen in Fig. 2 has three basic parts: the front cover, the rear cover and the center section. A large plastic window in the front cover permits film observations while 500-ft reels are in use and the cover closed. By loosening two thumbscrews, the front cover can be removed to permit the use of film reels larger than 500 ft. The rear cover is similar to the front cover. Located inside its back is a mounting for additional belts and sound-absorptive material for noise control. The center section of the case is a cast magnesium box having an open end. The closed or front end forms the panel for mounting the drive, take-up and feed mechanisms, footage counter and electrical components associated with the bias oscillator and playback amplifier. At either end are panels containing additional components for external electrical connections and controls (Fig. 3). This arrangement facilitates the adaptability of the recorder to different motor systems, control circuits and external electrical connections and allows the recorder to be operated completely enclosed.

The recorder may be modified for operation with 1500-ft instead of 500-ft reels in about 8 min by removing the three thumbscrews which mount the take-up and feed mechanisms and by remounting that mechanism in its new location (see Fig. 4). Except for belts, all items integral to this change are part of the recorder.

For transportation, two flush-type handles are attached to the ends of the center section.

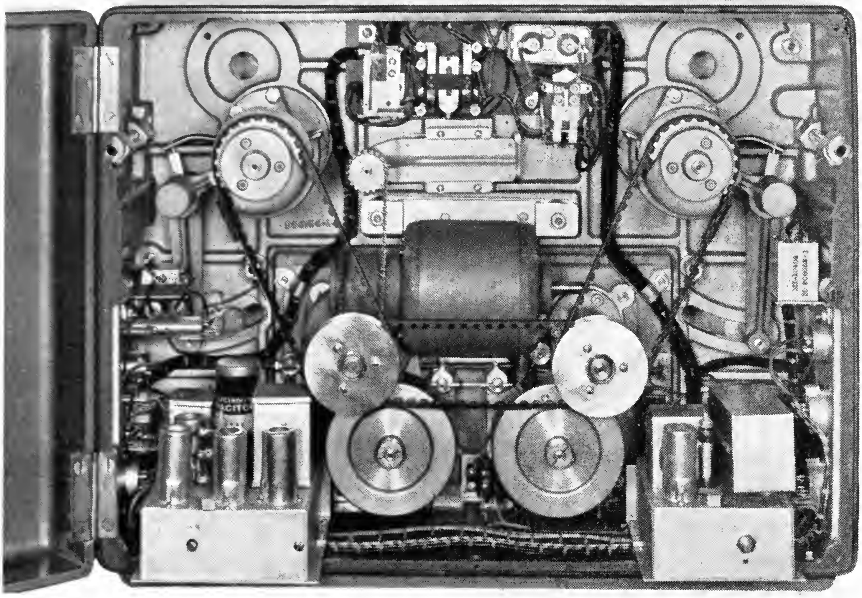


Fig. 4. PR-42 Portable Magnetic Recorder, rear cover opened.

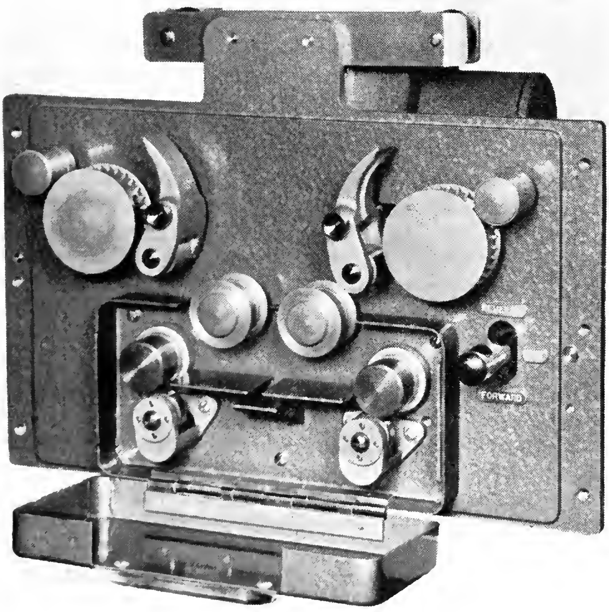


Fig. 5. PR-42 Film-Drive Mechanism, front view.

Drive Mechanism

The basic element of the drive mechanism is a mounting plate that contains the drive motor, mechanical filter system, magnetic heads, motor controls, guide rollers and other items integral to its operation. The mounting plate, as seen in Fig. 5, is a cast magnesium panel capable of being mounted for either portable or studio applications. The drive mechanism, using magnesium for all cast parts, has an overall weight of approximately 26 lb.

The drive motor is one of a new series of motors especially designed for magnetic recording equipment. The motor, which is mounted to the rear of the mechanism plate, contains a precision gear reduction unit to allow the drive sprocket to be coupled directly to the output shaft. Also coupled to the shaft, but extending to the rear, is an overrunning clutch assembly with driving media for the holdback sprocket, the take-up mechanism and the footage counter. Interchangeable gear reduction units provide for ratios varying between 10:1 and 125:9, depending upon the film speeds required and the type of motors used.

The film drive consists of two 32-tooth sprockets in a symmetrical path which includes two tension or filter rollers and two drum assemblies. Located in the film path, between the drums, are the magnetic record and monitor head assemblies. The film drive is described in detail in the paper "Twin-Drum Film-Drive Filter System for Magnetic Recorder-Reproducer" by Carl E. Hittle, immediately preceding this paper in this *Journal*.

A combination drive and holdback sprocket[5] was designed to replace the standard sprocket because it best fulfills the needs of the tight-loop system and will allow the recorder to be operated in either direction without sprocket changes. The sprocket pitch and tooth shape are dimensioned so that the face of only one tooth is driving or holding back the film at any given time. The sprocket will accommodate films with 0.6% shrinkage and 0.02% expansion. The area of contact between film and sprocket has been reduced from 90° in the earlier sprocket to 60° maximum for the new sprocket.

The tension or filter rollers are mounted on shafts attached to the ends of the roller arms. These arms are in turn pivoted from a fixed point. The arms are tied together by a spring and are separately grounded by additional springs. Figure 6 shows the mechanical filter system schematic. An oil-type dashpot is attached to the other end of the right roller arm by suitable linkages. The damping medium is a selected grade of silicone oil. The entire system is near critically damped with a resonant frequency of 1½ cycle/sec.

The drum assemblies, mounted in cast tubular housings identical with those of the holdback sprocket, have dynamically and statically balanced flywheels serving as inertia elements. Both drums are film driven.

The magnetic head[6] may be used for either single- or multiple-track applications. For single-track applications, there is a two-piece holder having a ball-and-socket type of anchorage. Through the mounting flange screws, the anchorage and four opposing setscrews bearing on the head, it is possible to give longitudinal, lateral and transverse adjustments[7] to the head as required. For 16mm and 35mm operations, a hardened stainless-steel shoe is placed in alignment with the magnetic heads, thereby maintaining an even plane of film across the magnetic head and an even pressure at the gap, thus minimizing wear. For 17½mm operation, the magnetic head is only 5½ mils from the center line of the film. Instead of using a shoe, the drums are tapered and flanged allowing the film to be guided from the perforated edge, thus assuring track location, uniform contact and minimum wear.

The motor-control-switch mechanism

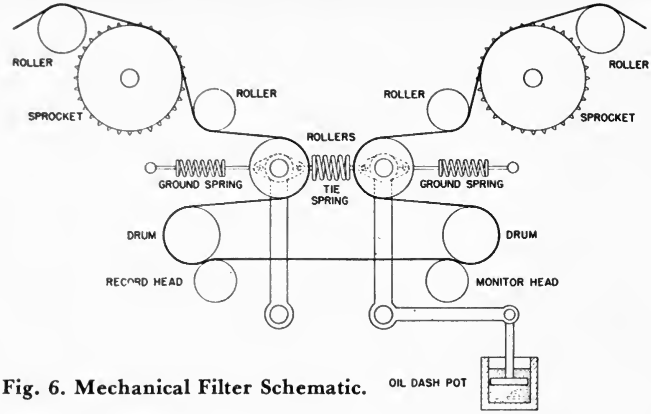
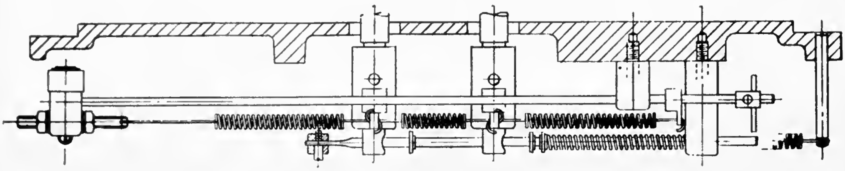


Fig. 6. Mechanical Filter Schematic.



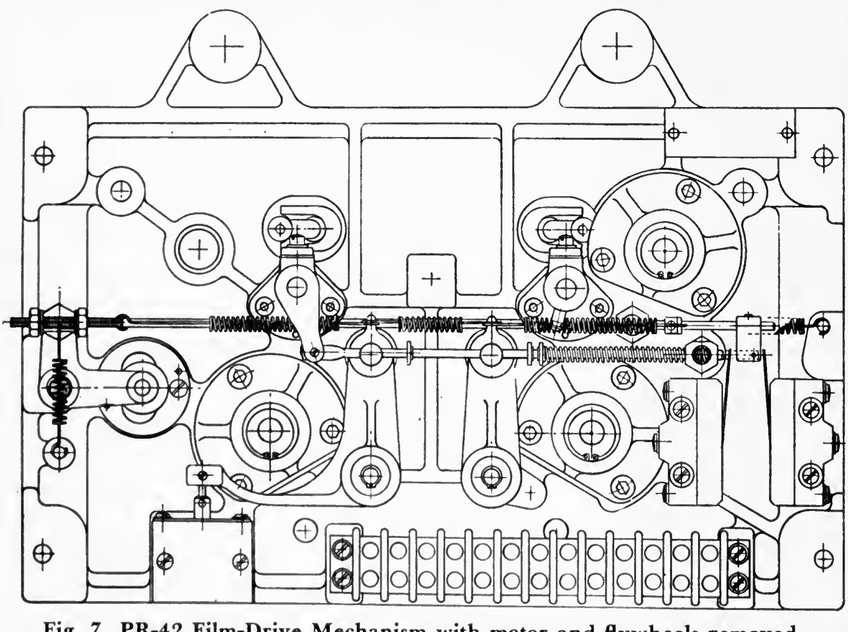


Fig. 7. PR-42 Film-Drive Mechanism with motor and flywheels removed.

is used for switching and for adjustments of the ground springs connected to the filter roller arms. Referring to Fig. 7, it may be seen that the filter ground springs have been arranged so that they are automatically tensioned through a bell-crank arrangement for the respective running directions of the mechanism. The damped filter roller ground spring is connected to the bell crank by an adjustable anchorage which permits quick adjustment of the filter roller balance. The undamped filter roller spring likewise has an adjustable anchorage, but is used for manufacturing convenience only. The center tie spring is permanently attached to the filter roller arms. The mechanical linkage, on which the undamped adjustable anchorage is mounted, also carries fingers that actuate microswitches that in turn control remotely mounted relays in the motor circuit. The motor-control switch consists of a bar moving vertically in an elongated slot. It is positively locked in the "off" position and released by pushing in on the bar to either of the operating positions.

The sprocket shoes are basically safety devices, since the film has a mechanically predetermined amount of wrap on each sprocket. Both shoes are held for normal clearance from the sprocket by a positive locking detent arrangement and spring tension. The drive sprocket shoe (Fig. 7) is mechanically linked with the filter rollers in such a fashion that when it is opened, the undamped filter roller is locked in its rest or innermost position and the damped filter roller is displaced from its rest position to a predetermined location. The film may then be threaded through the film-drive system in tight fashion. Upon releasing the drive-sprocket shoe, the filter rollers are freed to their normal positions and the film loop is thus automatically formed.

High permeability shielding around the motor and the magnetic heads is used to prevent hum pickup. Ball bearings have been used at all points except on the motor shafts.

Take-up and Feed Mechanisms

It has long been the desire of all associated with the motion picture industry to acquire an efficient mechanical take-up and feed mechanism. As a result, the take-up and feed mechanisms were designed with constant torque to guard against their failure during the operating cycle of a roll of film. Tests showed that with constant torque the film tension between the film reels and the take-up or holdback sprockets varied by ratios of 7:1 or 1:7, respectively, throughout the length of a 1500-ft roll of film wound on a 2-in. core. By varying the applied torque at the friction-clutch assembly in the new take-up and feed mechanisms (Fig. 8), it is possible to have near-constant film tensioning between the film reels and sprockets. Tests using a 1500-ft roll of film on a 2-in. core indicated that the tension varied only 2 oz throughout the length of the film roll.

The take-up and feed mechanisms are composed of identical subassemblies; therefore the mechanical construction will be discussed in terms of the take-up. The take-up is driven through an overrunning clutch mechanism located at the friction-clutch assembly, a precision rubber cog belt and a clutch mechanism coupled to the rear extension of the output shaft. For varying the amount of pressure needed during operation, suitable mechanical linkages are used to connect the adjustable compression spring to an extended portion of the sensing roller arm. This connection allows the spring compression to vary as required by the film pull on the sensing roller.

The decreasing weight of the film reel causes a small amount of overslipping at the friction-clutch assembly, since the pressure of the compression spring at a given instant is not sufficient to assure take-up of the film. At this given instant, the sensing roller relaxes its position in the slot to equal the slacking of the tension in the film loop from sprocket to take-up reel.

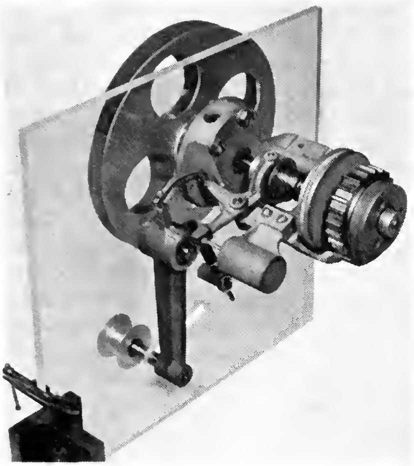


Fig. 8. Take-up Assembly, parts arrangement.

Fig. 9. MI-10278 Mixer Amplifier Case.

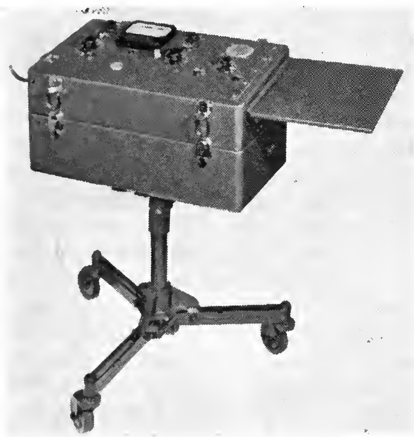


Fig. 10. MI-10278 Mixer Amplifier Case on Pedestal.

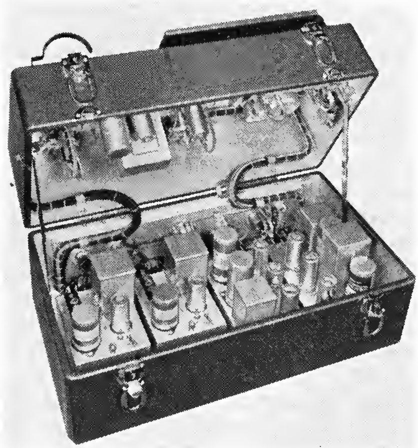


Fig. 11. MI-10278 Mixer Amplifier Case (internal arrangement).

By this action the sensing roller, through its linkages to the compression spring, causes the spring to be compressed, thus giving the needed additional pressure at the friction-clutch assembly. These minute impulses are continuous throughout the time required to transport the film through the recorder.

Also attached to the extended portion of the sensing roller arm is a spring with an adjustable anchorage and a dashpot. The dashpot softens the shock of the roller arm when the roller moves toward either of the extremities of the slot at starting or stopping, or in case of irregularities in the film loop. The dashpot also keeps the sensing roller from hunting

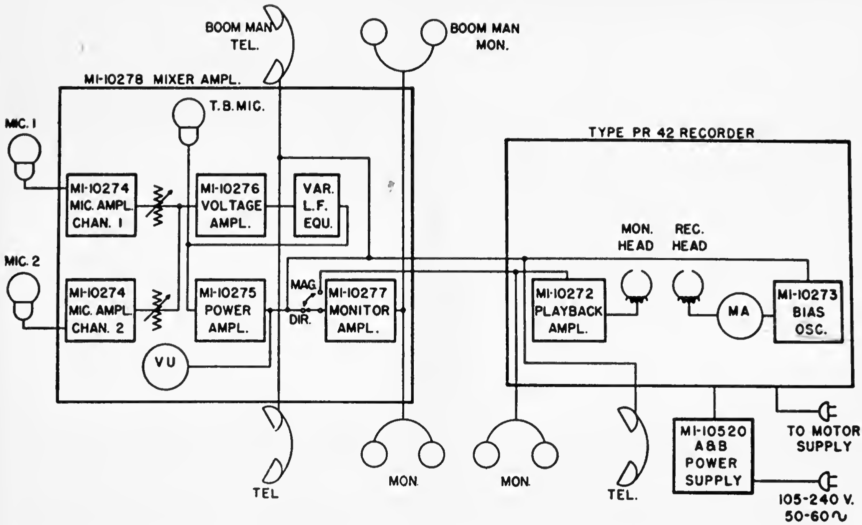


Fig. 12. Transmission Block Schematic.

during the normal operation of the recorder.

As a result of this arrangement, the film tensions between feed reel, holdback sprocket, take-up reel and drive sprocket are near constant at all times. Also, through the action of the overrunning clutch mechanisms, the operation of take-up and feed mechanism may be reversed according to the rotational action of the drive motor.

All recording amplifiers and recording control circuits are contained in the mixer amplifier case shown in Fig. 9, in the closed position ready for transportation. For operation, the top cover is removed and a writing surface attached to a hinge, normally located inside the cover, is folded to the right side of the case. This permits the mixer to keep his log and facilitates his written entries. On the left side is a hinged bracket which furnishes support for a sound-powered telephone set. The mixer case, ready for operation and on a collapsible pedestal, is shown in Fig. 10.

The internal arrangement of amplifiers and control panel is shown in Fig. 11. Plug-in amplifiers are used throughout, for maximum serviceability.

The electrical transmission circuit conforms to the block diagram shown in Fig. 12. The signal from two microphones is amplified by separate microphone amplifiers whose output is controlled by individual mixer pots, then combined and further amplified by means of a voltage amplifier. The signal is then conducted to the power amplifier, and hence directed to the recorder. The case containing the above-described amplifiers also contains a monitor amplifier whose input is normally bridged across the output of the recording amplifier. At the recorder the signal is combined with the bias current and fed to the recording head. In the recorder itself are contained a bias oscillator and a playback amplifier. The output from this playback amplifier is brought back to the amplifier case and is available to the mixer by pressing a button so it can be compared with the output from the direct monitor. All amplifiers located in the mixer amplifier case use the same tube type, namely, 12AY7. Only three

different tube types are used in the entire channel, each chosen to insure optimum operating efficiency and freedom from microphonics and tube noise. For instance, the two lowest-level stages in the playback amplifier employ RCA 5879 tubes which are selected to be equal in noise to RCA-1620's. In the bias oscillator the tube is a 12AU7 which has worked out very satisfactorily in previous similar applications.

Let us consider briefly the circuits of each amplifier. The microphone amplifiers each use one single 12AY7 tube. The two triode sections of these tubes are connected in cascade with sufficient feedback from input to output to keep distortion to a minimum and to stabilize the gain, so that changes in tube characteristics and component tolerances have only a negligible influence on the gain or frequency characteristic. The microphone amplifier input transformers provide facilities for working from 30-, 50-, 150- or 250-ohm microphones. These transformers have been especially designed so that one primary connection permits the interchangeable use of 30- or 50-ohm microphones, whereas another connection accommodates 150- or 250-ohm microphones. The change in frequency characteristic when working from these various impedances is negligible. Means are also incorporated in the microphone amplifiers to reduce the gain by 10 db if high-level pickup conditions should make this necessary. A toggle switch introduces equalization so that either velocity or pressure microphones can be used satisfactorily.

The voltage amplifier uses one 12AY7 tube connected in similar fashion as already described in the microphone amplifier. It also contains a switch for 10-db gain reduction which is normally in the circuit so that a reserve gain of 10 db is available should it be required. In addition to the amplifier circuit itself, there are also provided an 8000-cycle low-pass filter and a low-frequency boost circuit. The voltage amplifier chassis also contains a 400-cycle RC oscillator which may be used for system lineup purposes and for the recording of a reference tone for level adjustment of the transfer channel.

The power and monitor amplifiers employ identical circuits, except that a gain control potentiometer is added in the monitor amplifier and different secondary impedances are available at the output transformers. Three 12AY7 tubes are used to provide the necessary gain and power handling capacity. The output stage is a push-pull stage fed from a conventional phase splitter. The phase splitter is directly coupled to a driver stage. Negative feedback by means of a tertiary winding on the output transformer is applied to the driver stage cathode. An additional 12AY7 tube furnishes voltage gain employing a circuit similar to the microphone amplifier.

These five amplifiers are all housed together in an aluminum case (Fig. 10), the top surface of which contains all control facilities such as VU meters, mixer pots, power supply voltage metering switch, oscillator on-and-off switch, magnetic-direct monitoring switch and four steps of dialogue equalization. In addition, a pair of jacks has been provided for monitoring headsets of either 10- or 50-ohm impedance. A separate telephone circuit permits communication with the recordist and/or boom man. A talkback microphone is available to the mixer for slating and directions to the recordist and boom man during rehearsals. A pair of headset jacks has also been provided for a monitoring headset for the boom man.

As indicated before, the recorder itself contains a magnetic monitoring or playback amplifier and a bias oscillator. Two 5879 tubes and two 12AY7 tubes are used in the playback amplifier. The push-pull output stage is supplied by a conventional phase splitter which in turn is fed by a driver stage. Negative feedback from the output to the driver stage cathode is obtained by means of a

Fig. 13. MI-10520 Power Supply.

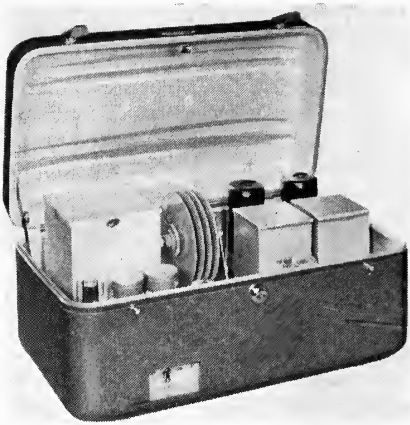


Fig. 14. MI-10520 Power Supply.

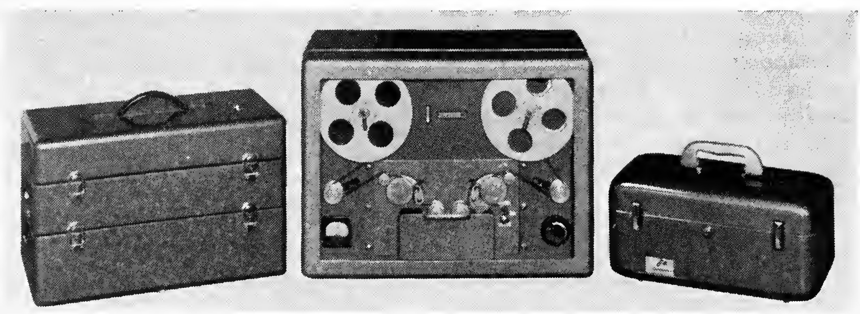


Fig. 15. Overall Channel.

tertiary winding on the output transformer. Two 5879 tubes are used in the first and second stage and stabilized with negative feedback from second stage output to first stage cathode. A gain control is located after the second 5879 tube. The magnetic reproducing head is connected to this amplifier through a special input transformer. The output of this amplifier is available at a pair of jacks for headset monitoring and also brought back to the mixer amplifier for magnetic monitoring at the disposal of the mixer. An equalizer circuit located within the amplifier provides an overall recording/reproducing frequency response virtually flat from 40 to 8000 cycles. The equalizer constants can be changed to take care of film speeds of 90, 45 or 36 fpm.

The bias oscillator utilizes a single 12AU7 tube and furnishes more than sufficient bias current for all presently manufactured magnetic emulsions. A meter which indicates bias current and which uses a germanium rectifier bridge circuit is mounted in the recorder front panel for convenient observation by the recordist. A bias control which normally needs no resetting has been located on the oscillator chassis itself and is available after opening of the recorder back cover. The application of bias to the record head is controlled by a 3-position switch located on the recorder

front panel. In the "play" and "off" positions no bias is applied to the record head, whereas in the "record" position, up to 20 ma of bias current are available. The bias oscillator chassis also contains a relay which is actuated whenever the bias current is turned off as, for instance, during rehearsals or playback or when the recorder is operated backwards. It also disconnects the oscillator from the output of the recording amplifier and provides the proper termination. This has been done as a precautionary measure in order to avoid accidental contamination of a recording. A separate relay transfers the recordist's monitor headset from the output of the playback amplifier to the recording line which normally supplies signal to the bias oscillator. This transfer takes place automatically whenever the recorder is not running so that the recordist always can hear when the mixer wants to communicate with him by means of the talkback microphone. This arrangement also permits the recordist to listen to rehearsals.

Two 6-conductor cables are used between the mixer amplifier and the recorder. These cables contain signal transmission circuits, telephone circuits, buzzer circuits and power circuits. A separate cable is needed between the recorder and the power supply.

Two types of power supplies are provided. An a-c power supply furnishes d-c heater current and load and line regulated B current (Figs. 13 and 14). In addition, a dynamotor supply will be available shortly which will permit the use of storage batteries for location work and will work in conjunction with the multiduty motor setup.

The weight of the mixer case complete with amplifiers and tubes and cover is 31 lb. The weight of the recorder with playback amplifier, bias oscillator, front and back cover is 76 lb, and the a-c power supply weighs 29 lb. All three units comprising the entire channel are shown in Fig. 15.

Summary

While this recording channel does not represent minimum weight and size facilities, it offers studio quality performance and provides among many others the conveniences listed below which normally would have to be sacrificed to reduce weight and bulk.

1. Versatility of film speeds and film widths, namely, speeds of 90, 45 or 36 fpm; film widths of 35, 17½ or 16mm.
2. Flexibility of drive motors:
   a. single-phase, 115-v a-c, 50 and 60 cycles,
   b. 3-phase, 220-v a-c, 50-, 60-cycle,
   c. multiduty motor which permits operation from 96-v storage battery or 208/230-v a-c, and
   d. selsyn interlock.
3. One to three tracks.
4. Forward and/or reverse direction of recording and reproducing.
5. Tight loop threading.
6. Overall recording and reproducing signal-to-noise ratio between 55 and 60 db can be obtained consistently at distortion of 2.5%.

References

1. Earl Masterson "35-mm magnetic recording system," *Jour. SMPE, 51:* 481–488, Nov. 1948.
2. O. B. Gunby, "Portable magnetic recording system," *Jour. SMPE, 52:* 613–618, June 1949.
3. Motion Picture Research Council Recommendation 58.301-B.
4. Proposed American Standard, Dimensions for Magnetic Sound Tracks on 35 mm and 17½ mm Motion Picture Film (First Draft), PH22.86, *Jour. SMPTE, 57:*72, July 1951.
5. J. S. Chandler, "Some theoretical considerations in the design of sprocket for continuous film movement," *Jour. SMPE, 37:* 164–176, Aug. 1941.
6. M. Rettinger, "A magnetic record-reproduce head," *Jour. SMPTE, 55:* 377–390, Oct. 1950.
7. Terms are those defined by N. M. Haynes, "Magnetic tape and head alignments nomenclature," *Audio Eng., 33:* 22, June 1949.

Constitution of the Society of Motion Picture and Television Engineers

ARTICLE I

Name

The name of this association shall be SOCIETY OF MOTION PICTURE AND TELEVISION ENGINEERS.

ARTICLE II

Objects

Its objects shall be: Advancement in the theory and practice of engineering in motion pictures, television, and the allied arts and sciences; the standardization of equipment and practices employed therein; the maintenance of a high professional standing among its members; and the dissemination of scientific knowledge by publication.

ARTICLE III

Meetings

There shall be an annual meeting and such other regular and special meetings as provided in the Bylaws.

ARTICLE IV

Eligibility for Membership

Any person of good character is eligible to become a member in any grade for which he is qualified in accordance with the Bylaws.

ARTICLE V

Officers

The officers of the Society shall be a President, an Executive Vice-President, a Past-President, an Engineering Vice-President, an Editorial Vice-President, a Financial Vice-President, a Convention Vice-President, a Secretary, and a Treasurer.

The term of office of all elected officers shall be for a period of two years.

The President shall not be eligible to succeed himself in office.

At the conclusion of his term of office the President automatically becomes Past-President.

Under conditions as set forth in the Bylaws, the office of Executive Vice-President may be vacated before the expiration of his term.

A vacancy in any office shall be filled for the unexpired portion of the term in accordance with the Bylaws.

ARTICLE VI

Sections

Sections may be established in accordance with the Bylaws.

ARTICLE VII

Board of Governors

The Board of Governors shall consist of the President, the Past-President, the five Vice-Presidents, the Secretary, the Treasurer, the Section Chairmen, and twelve elected Governors. An equal number of these elected Governors shall reside within the areas included in the Eastern time zone; the Central time zone; and the Pacific and Mountain time zones. The term of office of all elected Governors shall be for a period of two years.

ARTICLE VIII

Amendments

This Constitution may be amended as follows: Amendments may originate as recommendations within the Board of Governors, or as a proposal to the Board of Governors, by any ten members of voting grade; when approved by the Board of Governors as set forth in the Bylaws, the proposed amendment shall then be submitted for discussion at the annual meeting or at a regular or special meeting called as provided in the Bylaws. The proposed amendment, together with the discussion thereon, shall then be promptly submitted by mail to all members qualified to vote, as set forth in the Bylaws. Voting shall be by letter ballot mailed with the proposed amendment and discussion to the voting membership. In order to be counted, returned ballots must be received within sixty (60) days of the mailing-out date. An affirmative vote of two thirds of the valid ballots returned, subject to the above time limitations, shall be required to carry the amendment, provided one fifteenth of the duly qualified members shall have voted within the time limit specified herein.

BYLAWS OF THE SOCIETY OF MOTION PICTURE AND TELEVISION ENGINEERS

BYLAW I

Membership

Sec. 1. Membership of the Society shall consist of the following grades: Honorary members, Sustaining members, Fellows, Active members, Associate members and Student members.

An *Honorary member* is one who has performed eminent service in the advancement of engineering in motion pictures, television, or allied arts. An Honorary member shall be entitled to vote and to hold any office in the Society.

A *Sustaining member* is an individual, company, or corporation subscribing substantially to the financial support of the Society.

A *Fellow* is one who shall be not less than thirty years of age and who shall by his proficiency and contributions have attained to an outstanding rank among engineers or executives of the motion picture or television industries. A Fellow shall be entitled to vote and to hold any office in the Society.

An *Active member* is one who shall be not less than twenty-five years of age and shall be or shall have been either one or an equivalent combination of the following:

(a) An engineer or scientist in motion picture, television or allied arts. As such he shall have performed and taken responsibility for important engineering or scientific work in these arts and shall have been in the active practice of his profession for at least three years, or

(b) A teacher of motion picture, television or allied subjects for at least six years in a school of recognized standing in which he shall have been conducting a major course in at least one of such fields, or

(c) A person who by invention or by contribution to the advancement of engineering or science in motion picture, television or allied arts, or to the technical literature thereof, has attained a standing equivalent to that required for Active membership in (a), or

(d) An executive who for at least three years has had under his direction important engineering or responsible work in the motion picture, television or allied industries and who is qualified for direct supervision of the technical or scientific features of such activities. An Active member shall be entitled to vote and to hold any office in the Society.

An *Associate member* is one who shall be not less than eighteen years of age, and shall be a person who is interested in the study of motion picture or television technical problems or connected with the application of them. An Associate member is not privileged to vote, to hold office or to act as chairman of any committee, although he may serve upon any committee to which he may be appointed; and, when so appointed, shall be entitled to the full voting privileges on action taken by the committee.

A *Student member* is any person registered as a student, graduate or undergraduate, in a college, university, or other educational institution of like scholastic standing, who evidences interest in motion picture or television technology. Membership in this grade shall not extend more than one year beyond the termination of the student status described above. A student member shall have the same privileges as an Associate member of the Society.

Sec. 2. All applications for membership or transfer should be made on blank forms provided for the purpose, and shall give a complete record of the applicant's education and experience. Honorary and Fellow grades may not be applied for.

Sec. 3. (a) Honorary membership may be granted upon recommendation of the Honorary Membership Committee when confirmed first by a three-fourths majority vote of those present at a meeting of the Board of Governors, and then by a four-fifths majority vote of all voting members present at any regular meeting or at a special meeting called as stated in the bylaws. An Honorary member shall be exempt from the payment of all dues.

(b) Upon recommendation of the Fellow Award Committee, when confirmed by a three-fourths majority vote by those present at a meeting of the Board of Governors, an Active member may be made a Fellow.

(c) An Applicant for Active membership shall give as references at least two members of the grade applied for or of a higher grade. Applicants shall be elected to membership by a three-fourths majority vote of the entire membership of the appropriate Admissions Committee. An applicant may appeal to the Board of Governors if not satisfied with the action of the Admissions Committee, in which case approval of at least three-fourths of those present at a meeting of the Board of Governors shall be required for election to membership or to change the action taken by the Admissions Committee.

(d) An applicant for Associate membership shall give as reference one member of the Society, or two persons not members of the Society who are associated with the motion picture, television, or allied industry. Applicants shall be elected to membership by approval of the Chairman of the appropriate Admissions Committee.

(e) An applicant for Student membership shall be sponsored by a member of the Society, or by a member of the staff of the department of the institution he is attending, this faculty member not necessarily being a member of the Society. Applicants shall be elected to membership by approval of the Chairman of the appropriate Admissions Committee.

Sec. 4. Any member may be suspended or expelled for cause by a majority vote of the entire Board of Governors, provided he shall be given notice and a copy in writing of the charges preferred against him, and shall be afforded opportunity to be heard ten days prior to such action.

BYLAW II

Officers

Sec. 1. An officer or governor shall be an Honorary member, Fellow, or an Active member.

BYLAW III

Board of Governors

Sec. 1. The Board of Governors shall transact the business of the Society in accordance with the Constitution and Bylaws.

Sec. 2. The Board of Governors may act on special resolutions between meetings, by letter ballot authorized by the President. An affirmative vote from a majority of the total membership of the Board of Governors shall be required for approval of such resolutions.

Sec. 3. A quorum of ten members of the Board of Governors shall be present to vote on resolutions presented at any meeting. Unless otherwise specified, a majority vote of the Governors present shall constitute approval of a resolution.

Sec. 4. A member of the Board of Governors may not authorize an alternate to act or vote in his stead.

Sec. 5. Vacancies in the offices or on the Board of Governors shall be filled by the Board of Governors until the annual elections of the Society.

Sec. 6. The Board of Governors, when filling vacancies in the offices or on the Board of Governors, shall endeavor to appoint persons who in the aggregate are representative of the various branches or organizations of the industries interested in the activities of the Society to the end that there shall be no substantial predominance upon the Board, as the result of its own action, of representatives of any one or more branches or organizations of such industries.

Sec. 7. The time and place of all except special meetings of the Board of Governors shall be determined by the Board of Governors.

Sec. 8. Special Meetings of the Board of Governors shall be called by the President with the proviso that no meeting shall be called without at least seven days prior notice to all members of the Board by letter or telegram. Such a notice shall state the purpose of the meeting.

BYLAW IV

Administrative Practices

Sec. 1. Special rules relating to the administration of the Society and known as Administrative Practices shall be established by the Board of Governors and shall be added to or revised as necessary to the efficient pursuit of the Society's objectives.

BYLAW V

Committees

Sec. 1. All committees, except as otherwise specified, shall be formed and appointed in accordance with the Administrative Practices as determined by the Board of Governors.

Sec. 2. All committees, except as otherwise specified, shall be appointed to act for the term served by the officer charged with appointing the committees or until he terminates the appointment.

Sec. 3. Chairmen of the committees shall not be eligible to serve in such capacity for more than two consecutive terms.

Sec. 4. Standing Committees of the Society to be appointed by the President and confirmed by the Board of Governors are as follows:

Honorary Membership Committee
Journal Award Committee
Nominating Committee
Progress Medal Award Committee
Public Relations Committee
Samuel L. Warner Memorial Award Committee

Sec. 5. There shall be an Admissions Committee for each Section of the Society composed of a chairman and three members of which at least two shall be members of the Board of Governors.

Sec. 6. There shall be a Fellow Award Committee composed of all the officers and section chairmen of the Society under the chairmanship of the Past-President. In case the chairmanship is vacated it shall be temporarily filled by appointment by the President.

BYLAW VI

Meetings of the Society

Sec. 1. The location and time of each meeting or convention of the Society shall be determined by the Board of Governors.

Sec. 2. The grades of membership entitled to vote are defined in Bylaw I.

Sec. 3. A quorum of the Society shall consist in number of $\frac{1}{15}$ of the total of those qualified to vote as listed in the Society's records at the close of the last fiscal year before the meeting.

Sec. 4. The annual meeting shall be held during the fall convention.

Sec. 5. Special meetings may be called by the President and upon the request of any three members of the Board of Governors not including the President.

Sec. 6. All members of the Society in any grade shall have the privilege of discussing technical material presented before the Society or its Sections.

BYLAW VII

Duties of Officers

Sec. 1. The President shall preside at all business meetings of the Society and shall perform the duties pertaining to that office. As such he shall be the chief executive of the Society, to whom all other officers shall report.

Sec. 2. In the absence of the President, the officer next in order as listed in Article V of the Constitution shall preside at meetings and perform the duties of the President.

Sec. 3. The seven officers shall perform the duties separately enumerated below and those defined by the President:

(a) The Executive Vice-President shall represent the President, and shall be responsible for the supervision of the general affairs of the Society as directed by the President.

The President and the Executive Vice-President shall not both reside in the geographical area of the same Society Section, but one of these officers shall reside in the vicinity of the executive offices. Should the President or Executive Vice-President remove his residence to the same geographical area of the United States as the other, the office of Executive Vice-President shall immediately become vacant and a new Executive Vice-President shall be elected by the Board of Governors for the unexpired portion of the term.

(b) The Engineering Vice-President shall appoint all technical committees. He shall be responsible for the general initiation, supervision, and co-ordination of the work of these committees.

(c) The Editorial Vice-President shall be responsible for the publication of the Society's *Journal* and all other Society publications.

(d) The Financial Vice-President shall be responsible for the financial operations of the Society, and shall conduct them in accordance with budgets prepared by him and approved by the Board of Governors.

(e) The Convention Vice-President shall be responsible for the national conventions of the Society. He shall arrange for at least one annual convention to be held in the fall of the year.

Sec. 4. The Secretary shall keep a record of all meetings; and shall have the re-

sponsibility for the care and custody of records, and the seal of the Society.

Sec. 5. The Treasurer shall have charge of the funds of the Society and disburse them as and when authorized by the Financial Vice-President. He shall be bonded in an amount to be determined by the Board of Governors, and his bond shall be filed with the Secretary.

Sec. 6. Each officer of the Society, upon the expiration of his term of office, shall transmit to his successor a memorandum outlining the duties and policies of his office.

BYLAW VIII

Society Elections

Sec. 1. All officers and governors shall be elected to their respective offices by a majority of ballots cast by voting members in the following manner:

Nominations shall first be presented by a Nominating Committee appointed by the President, consisting of nine members, including a Chairman. The committee shall be made up of two Past-Presidents, three members of the Board of Governors not up for election, and four other voting members, not currently officers or governors of the Society. Nominations shall be made by three-quarters affirmative vote of the total Nominating Committee.

Not less than three months prior to the Annual Fall Meeting, the Board of Governors shall review the recommendations of the Nominating Committee, which shall have nominated suitable candidates for each vacancy.

Such nominations shall be final unless any nominee is rejected by a three-quarters vote of the Board of Governors present and voting. The Secretary shall then notify these candidates of their nomination. From the list of acceptances, not more than three names for each vacancy shall be selected by the Board of Governors and placed on a letter ballot. A blank space shall be provided on this letter ballot under each office, in which space the name of any voting member other than those suggested by the Board of Governors may be voted for. The balloting shall then take place. The ballot shall be enclosed with a blank envelope and a business reply envelope bearing the Secretary's address and a space for the member's name and address. One set of these shall be mailed to each voting member of the Society, not less than forty days in advance of the Annual Fall Meeting.

The voter shall then indicate on the ballot one choice for each vacancy, seal the ballot in the blank envelope, place this in the envelope addressed to the Secretary, sign his name and address on the latter, and mail it in accordance with the instructions printed on the ballot. No marks of any kind except those above prescribed shall be placed upon the ballots or envelopes. Voting shall close seven days before the opening session of the annual fall convention.

The sealed envelope shall be delivered by the Secretary to a Committee of Tellers appointed by the President at the annual fall convention. This committee shall then examine the return envelopes, open and count the ballots, and announce the results of the election.

The newly-elected officers and governors of the Society shall take office on January 1, following their election.

BYLAW IX

Dues and Indebtedness

Sec. 1. The annual dues shall be fifteen dollars ($15) for Fellows and Active members, ten dollars ($10) for Associate members, and five dollars ($5) for Student members, payable on or before January 1, of each year. Current or first year's dues for new members in any calendar year shall be at the full annual rate for those notified of election to membership on or before June 30; one half the annual rate for those notified of election to membership in the Society on or after July 1.

Sec. 2. (a) Transfer of membership to a higher grade may be made at any time subject to the requirements for initial membership in the higher grade. If the transfer is made on or before June 30, the annual dues of the higher grade are required. If the transfer is made on or after July 1, and the member's dues for the full year have been paid, one half of the annual dues of the higher grade is payable less one half the annual dues of the lower grade.

(b) No credit shall be given for annual dues in a membership transfer from a higher to a lower grade, and such transfers shall take place on January 1, of each year.

Sec. 3. Annual dues shall be paid in advance.

Sec. 4. Failure to pay dues may be considered just cause for suspension.

BYLAW X

Publications

Sec. 1. The Society shall publish a technical magazine to consist of twelve monthly issues, in two volumes per year. The editorial policy of the *Journal* shall be based upon the provisions of the Constitution and a copy of each issue shall be supplied to each member in good standing mailed to his last address of record. Copies may be made available for sale at a price approved by the Board of Governors.

BYLAW XI

Local Sections

Sec. 1. Sections of the Society may be authorized in any locality where the voting membership exceeds twenty. The geographic boundaries of each Section shall be determined by the Board of Governors. Upon written petition for the authorization of a Section of the Society, signed by twenty or more voting members, the Board of Governors may grant such authorization.

Section Membership

Sec. 2. All members of the Society of Motion Picture and Television Engineers in good standing residing within the geographic boundaries of any local Section shall be considered members of that Section.

Sec. 3. Should the enrolled voting membership of a Section fall below twenty, or should the technical quality of the presented papers fall below an acceptable level, or the average attendance at meetings not warrant the expense of maintaining that Section, the Board of Governors may cancel its authorization.

Section Officers

Sec. 4. The officers of each Section shall be a Chairman and a Secretary-Treasurer. The Section chairmen shall be ex-officio members of the Board of Governors and shall continue in such positions for the duration of their terms as chairmen of the local Sections. Each Section officer shall hold office for one year, or until his successor is chosen.

Section Board of Managers

Sec. 5. The Board of Managers shall consist of the Section Chairman, the Section Past-Chairman, the Section Secretary-Treasurer, and six voting members. Each manager of a Section shall hold office for two years. Vacancies shall be filled by appointment by the Board of Managers until the annual election of the Section.

Section Elections

Sec. 6. The officers and managers of a Section shall be voting members of the Society. All officers and managers shall be elected to their respective offices by a majority of ballots cast by the voting members residing in the geographical area of the Section. Not less than three months prior to the annual fall convention of the Society, nominations shall be presented to the Board of Managers of the Section by a Nominating Committee appointed by the Chairman of the Section, consisting of seven members, including a chairman. The committee shall be composed of the present Chairman, the Past-Chairman, two other members of the Board of Managers not up for election, and three other voting members of the Section not currently officers or managers of the Section. Nominations shall be made by a three-quarters affirmative vote of the total Nominating Committee. Such nominations shall be final, unless any nominee is rejected by a three-quarters vote of the Board of Managers, and in the event of such rejection the Board of Managers will make its own nomination.

The Chairman of the Section shall then notify the candidates of their nomination. From the list of acceptances, not more than three names for each vacancy shall be selected by the Board of Managers and placed on a letter ballot. A blank space shall be provided on this letter ballot under each office, in which space the name of any voting member other than those suggested by the Board of Managers may be voted for. The balloting shall then take place. The ballot shall be enclosed with a blank envelope and a business reply envelope bearing the local Secretary-Treasurer's address and a space for the member's name and address. One of these shall be mailed to each voting member of the Society residing in the geographical

area covered by the Section, not less than forty days in advance of the annual fall convention.

The voter shall then indicate on the ballot one choice for each office, seal the ballot in the blank envelope, place this in the envelope addressed to the Secretary-Treasurer, sign his name and address on the latter, and mail it in accordance with the instructions printed on the ballot. No marks of any kind except those above prescribed shall be placed upon the ballots or envelopes. Voting shall close seven days before the opening session of the annual fall convention. The sealed envelopes shall be delivered by the Secretary-Treasurer to his Board of Managers at a duly called meeting. The Board of Managers shall then examine the returned envelopes, open and count the ballots, and announce the results of the election.

The newly-elected officers and managers shall take office on January 1, following their election.

Section Business

Sec. 7. The business of a Section shall be conducted by the Board of Managers.

Section Expenses

Sec. 8. (a) At the beginning of each fiscal year, the Secretary-Treasurer of each section shall submit to the Board of Governors of the Society a budget of expenses for the year.

(b) The Treasurer of the Society shall deposit with each Section Secretary-Treasurer a sum of money for current expenses, the amount to be fixed by the Board of Governors.

(c) The Secretary-Treasurer of each Section shall send to the Treasurer of the Society, quarterly or on demand, an itemized account of all expenditures incurred during the preceding period.

(d) Expenses other than those enumerated in the budget, as approved by the Board of Governors of the Society, shall not be payable from the general funds of the Society without express permission from the Board of Governors.

(e) The Section Board of Managers shall defray all expenses of the Section not provided for by the Board of Governors, from funds raised locally.

(f) The Secretary of the Society shall, unless otherwise arranged, supply to each Section all stationery and printing necessary for the conduct of its business.

Section Meetings

Sec. 9. The regular meetings of a Section shall be held in such places and at such hours as the Board of Managers may designate. The Secretary-Treasurer of each Section shall forward to the Secretary of the Society, not later than five days after a meeting of a Section, a statement of the attendance and of the business transacted.

Constitution and Bylaws

Sec. 10. Sections shall abide by the Constitution and Bylaws of the Society and conform to the regulations of the Board of Governors. The conduct of Sections shall always be in conformity with the general policy of the Society as fixed by the Board of Governors.

BYLAW XII

Student Chapters

Sec. 1. Student Chapters of the Society may be authorized in any college, university, or technical institute of collegiate standing. Upon written petition for the authorization of a Student Chapter, signed by twelve or more Society members, or applicants for Society membership, and the Faculty Adviser, the Board of Governors may grant such authorization.

Chapter Membership

Sec. 2. All members of the Society in good standing who are attending the designated educational institution shall be eligible for membership in the Student Chapter, and when so enrolled they shall be entitled to all privileges that such Student Chapter may, under the Constitution and Bylaws, provide.

Sec. 3. Should the membership of the Student Chapter fall below ten, or the average attendance of meetings not warrant the expense of maintaining the organization, the Board of Governors may cancel its authorization.

Chapter Officers

Sec. 4. The officers of each Student Chapter shall be a Chairman and a Secretary-Treasurer. Each Chapter officer shall hold office for one year, or until his

successor is chosen. Where possible, officers shall be chosen in May to take office at the beginning of the following school year. The procedure for holding elections shall be prescribed in Administrative Practices.

Faculty Adviser

Sec. 5. A member of the faculty of the same educational institution shall be designated by the Board of Governors as Faculty Adviser. It shall be his duty to advise the officers on the conduct of the Chapter and to approve all reports to the Secretary and the Treasurer of the Society.

Chapter Expenses

Sec. 6. The Treasurer of the Society shall deposit with each Chapter Secretary-Treasurer a sum of money, the amount to be fixed by the Board of Governors. The Secretary-Treasurer of the Chapter shall send to the Treasurer of the Society at the end of each school year or on demand an itemized account of all expenditures incurred.

Chapter Meetings

Sec. 7. The Chapter shall hold at least four meetings per year. The Secretary-Treasurer shall forward to the Secretary of the Society at the end of each school year a report of the meetings for that year, giving the subject, speaker, and approximate attendance for each meeting.

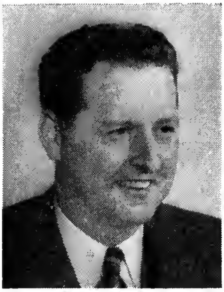
BYLAW XIII

Amendments

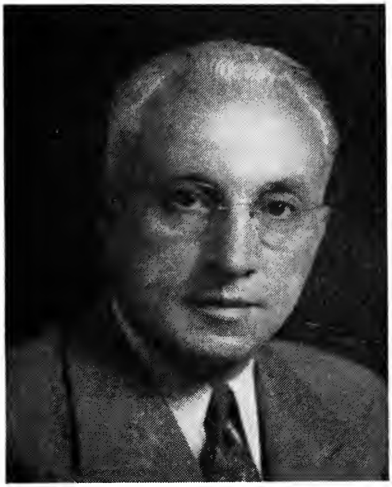
Sec. 1. Proposed amendments to these Bylaws may be initiated by the Board of Governors or by a recommendation to the Board of Governors signed by ten voting members. Proposed amendments may be approved at any regular meeting of the Society at which a quorum is present, by the affirmative vote of two-thirds of the members present and eligible to vote thereon. Such proposed amendments shall have been published in the *Journal* of the Society, in the issue next preceding the date of the stated business meeting of the Society at which the amendment or amendments are to be acted upon.

Sec. 2. In the event that no quorum of the voting members is present at the time of the meeting referred to in Sec. 1, the amendment or amendments shall be referred for action to the Board of Governors. The proposed amendment or amendments then become a part of the Bylaws upon receiving the affirmative vote of three-quarters of the entire membership of the Board of Governors.

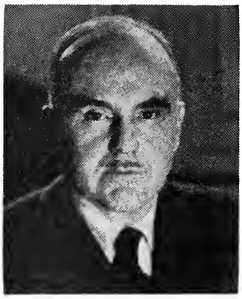
Officers of the Society April, 1952



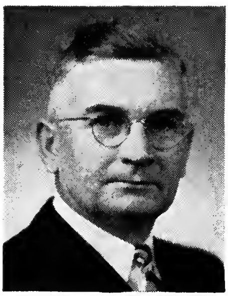
Herbert Barnett
Executive Vice-President
1951–52



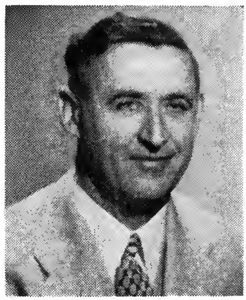
Peter Mole
President
1951–52



Earl I. Sponable
Past-President
1951–52



Fred T. Bowditch
Engineering Vice-President
1952–53

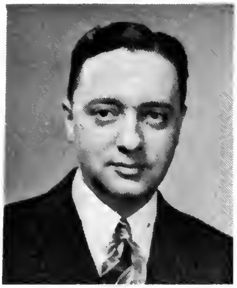


John G. Frayne
Editorial Vice-President
1951–52

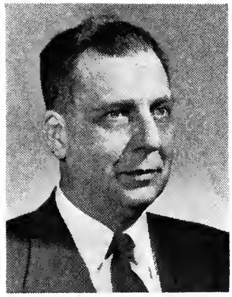
Frank E. Cahill, Jr.
Financial Vice-President
1952–53

William C. Kunzmann
Convention Vice-President
1951–52

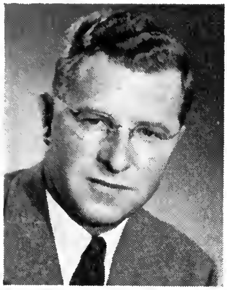
Robert M. Corbin
Secretary
1951–52



Barton Kreuzer
Treasurer, 1952–53



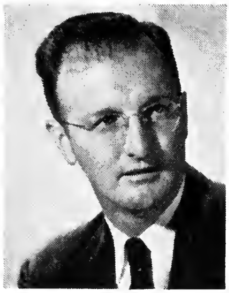
Frank E. Carlson
Governor, 1951–52



William B. Lodge
Governor, 1951–52

Thomas T. Moulton
Governor, 1951–52

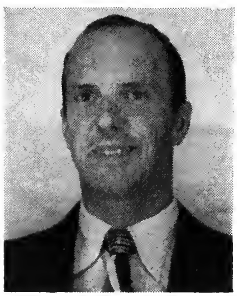
Oscar F. Neu
Governor, 1951–52



Norwood L. Simmons
Governor, 1951–52

Malcolm G. Townsley
Governor, 1951–52

Joseph E. Aiken
Governor, 1952–53



Fred G. Albin
Governor, 1952–53

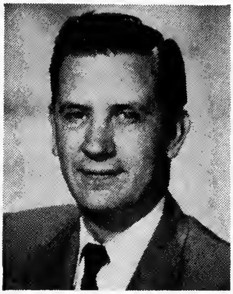
George W. Colburn
Governor, 1952–53

Ellis W. D'Arcy
Governor, 1952–53

John K. Hilliard
Governor, 1952–53

Axel G. Jensen
Governor, 1952–53

C. E. Heppberger
Governor, 1952



Vaughn C. Shaner
Governor, 1952

E. M. Stifle
Governor, 1952

OFFICERS AND MANAGERS OF SECTIONS

ATLANTIC COAST: Chairman, E. M. Stifle; *Secretary-Treasurer*, H. C. Milholland; *Managers*, E. A. Bertram, H. A. Chinn, F. N. Gillette, Richard Hodgson, D. B. Joy, John G. Stott.

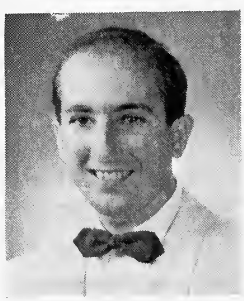
CENTRAL: Chairman, C. E. Heppberger; *Secretary-Treasurer*, J. L. Wassell; *Managers*, E. E. Bickel, W. C. Eddy, I. F. Jacobsen, K. M. Mason, R. H. Ray, M. G. Townsley.

PACIFIC COAST: Chairman, Vaughn C. Shaner; *Secretary-Treasurer*, P. C. Caldwell; *Managers*, F. G. Albin, A. C. Blaney, L. G. Dunn, A. M. Gundelfinger, W. F. Kelley, R. E. Lovell.

STUDENT CHAPTER OFFICERS

NEW YORK UNIVERSITY:
Under Reorganization

UNIVERSITY OF SOUTHERN CALIFORNIA: Chairman, Donald Stern; *Secretary-Treasurer*, Arthur Schneider



Donald Stern
Chairman, 1952

Treasurer's Report—January 1 — December 31, 1951

CASH			
Cash on Deposit, Regular Account, Chase National Bank, January 1, 1951		$30,093.92	
Net Receipts		(27,857.40)	
Cash on Deposit, Regular Account, December 31, 1951			$ 2,236.52
Cash on Deposit, Payroll Account, Chase National Bank, January 1, 1951	—		
Deposits	41,400.00		
Total		41,400.00	
Disbursements		41,302.00	
Cash on Deposit, Payroll Account, December 31, 1951			98.00
Petty Cash Fund			200.00
Total Cash on Deposit and on Hand			2,534.52
INVESTMENTS			
Savings Accounts, January 1, 1951	31,419.71		
Add: Interest Credited	927.63		
Total	32,347.34		
Less: Account Closed	5,138.43		
Savings Accounts, December 31, 1951		27,208.91	
U.S. Government Bonds (at cost)		60,000.00	
Total Investments			87,208.91
Total Cash and Investments, December 31, 1951			$89,743.43

Respectfully submitted,
FRANK E. CAHILL, Jr., *Treasurer*

Summary of Financial Condition—Dec. 31, 1951

ASSETS (What Your Society Owns)	
Cash on Hand and in Bank	$ 2,534.52
Savings Accounts	27,208.91
U.S. Government Bonds (at cost)	60,000.00
Accounts Receivable	21,719.86
Test Film Inventory	53,019.81
Test Film Equipment (memo value)	1.00
Office Furniture and Equipment (memo value)	1.00
Prepaid Expenses	63.00
Total Assets	$164,548.10
LIABILITIES (What Your Society Owes)	
Accounts Payable	$ 22,640.07
Due to Customers	860.85
Membership Dues Received in Advance	12,687.85
N.Y.C. Sales Tax Payable	14.38
Reserve for 1955 Five-Year Index	500.00
Total Liabilities	$ 36,703.15
MEMBERS' EQUITY (What Your Society Is Worth)	127,844.95
Total Liabilities and Members' Equity	$164,548.10

Statement of Income and Expenses

January 1 — December 31, 1951

Test Film Operations		
Test Film Sales	$133,746.17	
Cost of Test Films Sold	79,148.48	
Net Income From Test Film Operations		$54,597.69
Publications Operations		
Publications Income	$ 20,774.36	
Cost of Publications	45,467.44	
Net Loss From Publications Operations		(24,693.08)
Other Operations		
Other Operations Income	$ 388.49	
Cost of Other Operations	710.56	
Net Loss From Other Operations		(322.07)
Other Income		
Membership Dues	$ 60,511.51	
Interest Earned	2,454.70	
Miscellaneous Income	101.11	
Total Other Income		63,067.32
Total Operating Income		$92,649.86
Operating Expenses		
Engineering	$ 13,026.44	
Administrative	59,866.31	
Officers	108.85	
Sections and Chapters	2,700.00	
Affiliations	1,385.00	
Conventions	1,230.06	
Total Operating Expenses		78,316.66
Net Operating Income		$14,333.20
Other Deductions		
Depreciation of Test Film Equipment	$ 3,729.85	
Excess in Reserve for 1950 Five-Year Index	(453.53)	
Provision for 1955 Five-Year Index	500.00	
Total Other Deductions		3,776.32
Excess of Income Over Expenses		$10,556.88

The foregoing financial statements were prepared from the records of the Society for the year 1951 and reflect the results of operations for that year. The records and financial statements were audited for the year ended December 31, 1951, by Wilbur A. Smith, Certified Public Accountant, New York City, and are in conformity with that audit.

Ralph B. Austrian, *Financial Vice-President*

Membership Report

For Year Ended December 31, 1951

	Hon.	Sust.	Fel.	Act.	Assoc.	Stud.	Total
Membership, January 1, 1951	4	79	198	931	1887	184	3283
New Members		2		171	291	67	531
Reinstatements				10	20	6	36
	4	81	198	1112	2198	257	3850
Resignations		−2	−2	−15	−27	−5	−51
Deceased	−1		−3	−5	−8		−17
Delinquent		−3	−2	−72	−194	−23	−294
	3	76	191	1020	1969	229	3488
Changes in Grade:							
Active to Fellow			16	−16			
Associate to Active				114	−114		
Student to Associate					14	−14	
Active to Associate				−4	4		
Membership, December 31, 1951	3	76	207	1114	1873	215	3488

Nonmember Subscription Report

For Year Ended December 31, 1951

Subscriptions, January 1, 1951	575
New Subscriptions and Previous Cutoffs	892
	1467
Cutoffs and Expirations	439
Subscriptions, December 31, 1951	1028

Awards

In accordance with the provisions of the Administrative Practices of the Society and the regulations for granting the Journal Award, the Progress Medal Award, the Samuel L. Warner Memorial Award and the David Sarnoff Gold Medal Award, a list of names of previous recipients and the reasons for the awards are published annually in the *Journal* as follows:

Journal Award

The Journal Award Committee shall consist of five Fellows or Active members of the Society, appointed by the President and confirmed by the Board of Governors. The Chairman of the Committee shall be designated by the President.

At the fall convention of the Society a Journal Award Certificate shall be presented to the author or to each of the authors of the most outstanding paper originally published in the *Journal* of the Society during the preceding calendar year.

Other papers published in the *Journal* of the Society may be cited for Honorable Mention at the option of the Committee, but in any case should not exceed five in number.

The Journal Award shall be made on the basis of the following qualifications:

(1) The paper must deal with some technical phase of motion picture engineering.

(2) No paper given in connection with the receipt of any other Award of the Society shall be eligible.

(3) In judging of the merits of the paper, three qualities shall be considered, with the weights here indicated: (a) technical merit and importance of material, 45%; (b) originality and breadth of interest, 35%; and (c) excellence of presentation of the material, 20%.

A majority vote of the entire Committee shall be required for the election to the Award. Absent members may vote in writing.

The report of the Committee shall be presented to the Board of Governors at their July meeting for ratification.

These regulations, a list of the names of those who have previously received the Journal Award, the year of each Award, and the titles of the papers shall be published annually in the *Journal* of the Society. In addition, the list of papers selected for Honorable Mention shall be published in the *Journal* of the Society during the year current with the Award.

The recipients are listed below by year, with the date of *Journal* publication given after the title.

1934, P. A. Snell, "An introduction to the experimental study of visual fatigue," May 1933.

1935, L. A. Jones and J. H. Webb, "Reciprocity law failure in photographic exposure," Sept. 1934.

1936, E. W. Kellogg, "A comparison of variable-density and variable-width systems," Sept. 1935.

1937, D. B. Judd, "Color blindness and anomalies of vision," June 1936.

1938, K. S. Gibson, "The analysis and specification of color," Apr. 1937.

1939, H. T. Kalmus, "Technicolor adventures in cinemaland," Dec. 1938.

1940, R. R. McNath, "The surface of the nearest star," Mar. 1939.

1941, J. G. Frayne and Vincent Pagliarulo, "The effects of ultraviolet light on variable-density recording and printing, June 1940.

1942, W. J. Albersheim and Donald MacKenzie, "Analysis of soundfilm drives," July 1941.

1943, R. R. Scoville and W. L. Bell, "Design and use of noise-reduction bias systems," Feb. 1942 (Award made Apr. 1944).

1944, J. I. Crabtree, G. T. Eaton and M. E. Muehler, "Removal of hypo and silver salts from photographic materials as affected by the composition of the processing solutions," July 1943.

1945, C. J. Kunz, H. E. Goldberg and C. E. Ives, "Improvement in illumination efficiency of motion picture printers," May 1944.
946, R. H. Talbot, "The projection life of film," Aug. 1945.
1947, Albert Rose, "A unified approach to the performance of photographic film, television pickup tubes, and the human eye," Oct. 1946.
1948, J. S. Chandler, D. F. Lyman and L. R. Martin, "Proposals for 16-mm and 8-mm sprocket standards," June 1947.
1949, F. G. Albin, "Sensitometric aspect of television monitor-tube photography," Dec. 1948.
1950, Frederick J. Kolb, Jr., "Air cooling of motion picture film for higher screen illumination," Dec. 1949.
1951, A. B. Jennings, W. A. Stanton and J. P. Weiss, "Synthetic color-forming binders for photographic emulsions," Nov. 1950.

The present Chairman of the Journal Award Committee is Frederick J. Kolb, Jr.

Progress Medal Award

The Progress Medal Award Committee shall consist of five Fellows or Active members of the Society, appointed by the President and confirmed by the Board of Governors. The Chairman of the Committee shall be designated by the President.

The Progress Medal may be awarded each year to an individual in recognition of any invention, research or development which, in the opinion of the Committee, shall have resulted in a significant advance in the development of motion picture technology.

Any member of the Society may recommend persons deemed worthy of the Award. The recommendation in each case shall be in writing and in detail as to the accomplishments which are thought to justify consideration. The recommendation shall be seconded in writing by any two Fellows or Active members of the Society, who shall set forth their knowledge of the accomplishments of the candidate which, in their opinion, justify consideration.

A majority vote of the entire Committee shall be required to constitute an Award of the Progress Medal. Absent members may vote in writing.

The report of the Committee shall be presented to the Board of Governors at their July meeting for ratification.

The recipient of the Progress Medal shall be asked to present a photograph of himself to the Society and, at the discretion of the Committee, may be asked to prepare a paper for publication in the *Journal* of the Society.

These regulations, a list of the names of those who have previously received the Medal, the year of each Award and a statement of the reason for the Award shall be published annually in the *Journal* of the Society.

Awards have been made as follows:

1935, E. C. Wente, for his work in sound recording and reproduction, Dec. 1935.
1936, C. E. K. Mees, for his work in photography, Dec. 1936.
1937, E. W. Kellogg, for his work in sound reproduction, Dec. 1937.
1938, H. T. Kalmus, for his work in developing color motion pictures, Dec. 1938.
1939, L. A. Jones, for his scientific researches in photography, Dec. 1939.
1940, Walt Disney, for his contributions to motion picture photography and sound recording of feature and short cartoon films, Dec. 1940.
1941, G. L. Dimmick, for his development activities in motion picture sound recording, Dec. 1941.
No Awards were made in 1942 and 1943.
1944, J. G. Capstaff, for his research and development of films and apparatus used in amateur cinematography, Jan. 1945.
No Awards were made in 1945 and 1946.
1947, J. G. Frayne, for his technical achievements and the documenting of his work in addition to his contributions to the field of education and his inspiration to his fellow engineers, Jan. 1948.
1948, Peter Mole for his outstanding achievements in motion picture studio

lighting which set a pattern for lighting techniques and equipment for the American motion picture industry, Jan. 1949.

1949, Harvey Fletcher for his outstanding contributions to the art of recording and reproducing of sound for motion pictures, Oct. 1949

1950, V. K. Zworykin, for his outstanding contributions to the development of television, Dec. 1950.

1951, Earl I. Sponable, for outstanding contributions to technical advancement of the motion picture art, particularly with respect to sound on film, color and large-screen television, Dec. 1951.

The present Chairman of the Progress Medal Award Committee is D. B. Joy.

Samuel L. Warner Memorial Award

Each year the President shall appoint a Samuel L. Warner Memorial Award Committee consisting of a chairman and four members. The chairman and committee members must be Active Members or Fellows of the Society. In considering candidates for the Award, the committee shall give preference to inventions or developments occurring in the last five years. Preference should also be given to the invention or development likely to have the widest and most beneficial effect on the quality of the reproduced sound and picture. A description of the method or apparatus must be available for publication in sufficient detail so that it may be followed by anyone skilled in the art. Since the Award is made to an individual, a development in which a group participates should be considered only if one person has contributed the basic idea and also has contributed substantially to the practical working out of the idea. If, in any year, the committee does not consider any recent development to be more than the logical working out of details along well-known lines, no recommendation for the Award shall be made. The recommendation of the committee shall be presented to the Board of Governors at the July meeting.

The purpose of this Award is to encourage the development of new and improved methods or apparatus designed for sound-on-film motion pictures, including any step in the process.

Any person, whether or not a member of the Society of Motion Picture and Television Engineers, is eligible to receive the Award.

The Award shall consist of a gold medal suitably engraved for each recipient. It shall be presented at the Fall Convention of the Society, together with a bronze replica.

These regulations, a list of those who previously have received the Award, and a statement of the reason for the Award shall be published annually in the *Journal* of the Society. The recipients have been:

1947, J. A. Maurer, for his outstanding contributions to the field of high-quality 16-mm sound recording and reproduction, film processing, development of 16-mm sound test films, and for his inspired leadership in industry standardization (citation published, Jan. 1948).

1948, Nathan Levinson, for his outstanding work in the field of motion picture sound recording, the intercutting of variable-area and variable-density sound tracks, the commercial use of control track for extending volume range, and the use of the first soundproof camera blimps (citation published, Jan. 1949).

1949, R. M. Evans, for his outstanding work in the field of color motion picture films, including research on visual effects in photography and development work on commercial color processes (citation published, Oct. 1949).

1950, Charles R. Fordyce, for his efforts in and achievement of the development of triacetate safety base film (citation published, Dec. 1950).

1951, Earl I. Sponable, for years of research and development in recording of sound on film (citation published Dec. 1951).

The present Chairman of the Samuel L. Warner Memorial Award Committee is Glenn L. Dimmick.

David Sarnoff Gold Medal Award

The David Sarnoff Gold Medal Award Committee, appointed by the President, shall consist of five Fellows, Honorary Members or former recipients of some formal Society Award, each of whom shall be qualified to judge the importance or value of current work in some technical phase of the broad field of television engineering, whether in research, development, design, manufacture, operation, or in any similar phase of theater television.

The award shall consist of a gold medal, together with a bronze replica and a citation, stating the recipient's qualifications.

The David Sarnoff Gold Medal may be awarded each year to any qualified individual, whether or not currently a member of this Society, in recognition of recent technical contributions to the art of television, to encourage the development of new techniques, new methods and new equipment which hold promise for the continued improvement of television, preference to be given for work having reached completion within the preceding five years.

Recommendations of the Committee and a report of its deliberations shall be presented to the Board of Governors three months in advance of the time for presentation (at the July meeting of the Board, for presentation at the Fall Convention). Any member of the Society may recommend persons deemed worthy of the Award. The recommendation in each case shall be in writing and in detail as to the accomplishments which are thought to justify consideration.

These regulations, a list of the names of those who have previously received the medal, the year of each Award and a statement of the reason for the Award shall be published annually in the *Journal* of the Society. The first recipient is:

1951, Otto H. Schade, for his outstanding accomplishments in the fields of television and motion picture science and engineering, in outlining the potentialities of television and film systems as to fidelity of photography and reproduction of images (citation published Dec. 1951).

The present Chairman of the David Sarnoff Gold Medal Award Committee is Pierre Mertz.

HONORARY MEMBERS

Lee de Forest
Edward W. Kellogg
A. S. Howell
V. K. Zworykin

The distinction of Honorary Membership in the Society is awarded to living pioneers whose basic contributions when examined through the perspective of time represent a substantial forward step in the recorded history of the arts and sciences with which the Society is most concerned.

SMPTE HONOR ROLL

Louis Aimé Augustin Le Prince
William Friese-Greene
Thomas Alva Edison
George Eastman
Frederic Eugene Ives
Jean Acme Le Roy
C. Francis Jenkins
Eugene Augustin Lauste
William Kennedy Laurie Dickson
Edwin Stanton Porter
Herman A. DeVry
Robert W. Paul
Frank H. Richardson
Leon Gaumont
Theodore W. Case
Edward B. Craft
Samuel L. Warner
Louis Lumiere
Thomas Armat

Elevation to the Honor Roll of the Society is granted to each distinguished pioneer who during his lifetime was awarded Honorary Membership or whose work was recognized subsequently as fully meriting that award.

1952 Nominations

Candidates for election to national office of the Society are now being considered by the Nominating Committee. The eleven vacancies which will occur at the end of 1952 and are to be filled by this year's election are the offices of President, Executive Vice-President, Editorial Vice-President, Convention Vice-President, Secretary, two Governors from the West, two Governors from the Central area, and two Governors from the East. Names of the incumbents will be found on the inside back cover of each issue of the *Journal.*

Members in the Honorary, Fellow and Active Grades are invited by the Chairman of the Nominating Committee to submit their suggestions for candidates at the earliest possible dates. Address them to Earl I. Sponable, Movietonews, Inc., 460 W. 54th St., New York 19, N.Y.

Papers on Photographic Instrumentation

Instrumentation is the subject of this year's symposium of the Society of Photographic Engineers, to be held on June 4 and 5 at the Naval Ordnance Laboratory, White Oak, Md., according to information from SPE President Edward K. Kaprelian. The symposium will cover equipments, materials and techniques involved in the recording of data. Papers relating to high-speed cinematography will not be presented. Information about possible instrumentation papers will be welcomed by the symposium chairman, D. Max Beard, 4304 S. Capitol, Washington 20, D.C.

Book Reviews

Television Engineering (Second Edition)

By D. G. Fink. Published (1952) by McGraw-Hill, 330 W. 42 St., New York 36. i-xiv + 690 pp. + 12 pp. appendix + 19 pp. index. 512 illus. 6 × 9 in. Price $8.50.

Mr. Fink is one of those all too rare individuals—an engineer who can write. His previous books have been noted for their clear, lucid style and one would be disappointed if this one were not up to his previous standards. As a matter of fact, it is, if anything, superior to his earlier books in this respect and he has succeeded in turning out a text book for television engineering which is extremely clear and well written.

The book covers the entire field of television engineering starting with the fundamentals and progressing to a fairly detailed description of commercial television transmitting studio and receiving equipment. Two chapters of the book are devoted to an especially good description of color television which includes a consideration of color fundamentals and an objective study of the various systems which have been proposed for the transmission of television pictures and color. Television engineering covers such a wide variety of subject matter, drawing as it does upon combinations of practically all of the physical sciences, that any attempt to cover the entire system in one book will inevitably result in treatment which will seem superficial to the specialists. For example, in his discussion of radio wave propagation, Mr. Fink barely mentions the important work which was done by the FCC Ad Hoc Committee in connection with the determination of a terrain factor which describes the deviation of the median signal intensity from the smooth earth value because of the irregularities in the earth surface. Again, his discussion of the definition obtainable from the various components in the television system is entirely in terms of the resolving power of the various components. He must be ignoring the important work of Schade and

others who have shown that this is not an adequate criterion for picture definition.

The treatment of such a wide variety of subject matter probably leads inevitably to errors of fact which occur from time to time in the book. For example, an equivalent circuit which is supposed to show the input impedance of a balun is shown in Fig. 283; this circuit has a series LC circuit presumably resonant at the center of the frequency band shunted across the input terminals, so that input impedance of this frequency can be a short circuit. Again, on page 326, there is the following description of defraction of energy past the horizon: "Defraction occurs when the instant energy, following tangentially on the rim of the obstacle, is re-radiated from absorbing points on the rim." Even aside from the contradiction in terms involved in re-radiation from an *absorbing* object, this is surely not an accurate description of the phenomena of defraction.

The criticisms of the book described above were meant to illustrate the inevitable difficulties which arise in covering so much territory in one volume and not to deprecate what, in general, represents a very excellent job in doing what it was intended to do. The beginning student of television engineering or the specialist attempting to obtain a broad background in fields other than his own will find the book well organized, readable, and, with a few exceptions such as those noted above, accurate.—*McIntosh & Inglis*, Consulting Radio Engineers, 777 14th St., N.W., Washington 5, D.C.

Prism and Lens Making (Second Edition)

By F. Twyman. Published (1952) by Hilger & Watts Ltd., 98 St. Pancras Way, London, N.W. 1. Distributed in U.S.A. by the Jarrell-Ash Co., 165 Newbury St., Boston, Mass. i-viii + 590 pp. + 27 pp. appendix + 5 pp. bibliography + 7 pp. index. 260 illus. $5\frac{1}{2} \times 8\frac{1}{2}$ in. Price $11.25.

Although this is called a second edition of Twyman's 1942 book on prism and lens making, it is so much larger than the original (629 pages against the former 178) that it might almost be regarded as a new work. Where the previous treatment was stilted and severe, the new is easy to read and full of anecdotes and illustrative material of every kind. Indeed, the number of references to both ancient and recent authorities is extraordinary, and the writing is in the best tradition of Rayleigh or Dennis Taylor.

The chief charge against the previous edition was that only the procedures and techniques in use by Adam Hilger Ltd. were described. This was not very surprising as Mr. Twyman is the *emeritus* Managing Director of Hilger's, but in the new edition this is no longer the case. The author has gone to the greatest trouble to ascertain the methods used by other manufacturers (mainly, however, in England), and has described them impartially. This of course increases the value of the book very greatly, since Hilger's production is small in quantity but wide in variety and of the highest quality, while in some other companies the need for large-scale or mass production of lower-grade lenses has led to the development of entirely different manufacturing procedures.

In addition to a survey of the regular methods for the grinding, polishing, centering and cementing of lenses and prisms, several new chapters have been added dealing with such subjects as optical crystals and plastics and the manufacture of optical elements from them, microscope objectives, large astronomical objectives and mirrors, the surface treatment of lenses, spectacle lenses, and an excellent summary of the methods available for the generation of nonspherical surfaces. Almost 100 pages are devoted to the testing of optical work, both on the individual surfaces and on the completed systems. The tests of Fizeau, Foucault, Newton, Hartmann, Zernicke, and others are fully described, and in a separate chapter the applications of the author's well-known interferometers receive extensive treatment. The nature of glass and its annealing, and workshop tests for optical glass, are well covered.

Among the useful appendices there is a glossary of equivalent terms used in the optical industry in English, French and German. There is an extensive bibliography, and a good index. The paper and printing are excellent, but the review copy as received was poorly bound and

the cover was already falling off. Misprints are negligibly few. This excellent book can be very strongly recommended to all who have a close connection with the optical industry, or any occasion to grind and polish a lens.—*R. Kingslake*, Optical Design Dept., Hawk-Eye Works, Eastman Kodak Co., Rochester 4, N.Y.

Dynamics of the Film

By Joseph and Harry Feldman. Published (1952) by Hermitage House, 8 W. 13 St., New York 11. 241 pp. + 3 pp. bibliography + 2 pp. periodicals listing + 7 pp. index. Illustrated. $5\frac{1}{2} \times 8$ in. Price $3.50.

The main risk in attempting to "popularize" a difficult subject, especially in the field of aesthetics, lies in depriving it of all human and artistic warmth and in reducing it to a mere mechanical stratagem.

In this pitfall is precisely where the Messrs. Feldman have landed. Their book, intended purposely "for the BIG audience of movie-goers," fails to convey the meaning and essence of a film's overall dramatic impact. It is a case of not seeing the forest for the trees, and their analysis of the basic elements of a film constitutes a *reductio ad absurdum* of the approach they have chosen.

To some extent, they seem aware of their predicament. They try to tone down their dogmatic over-simplifications by hedging with carefully worded reservations. One must regretfully state, however, that the book's worthy aim of explaining the nature of film art to the general public falls very short of its fulfillment.—*George L. George*, Screen Directors Guild, 133 E. 40 St., New York 16.

Standards for single-line diagrams for use in both power and communication work combined in one volume in The American Standard Graphical Symbols for Single (One) Line Electrical Engineering Diagrams, Z32.1.1-1951, published by the American Standards Association, 70 E. 45 St., New York 17, at $1.40 per copy. This standard coordinates and modifies the single-line diagrams contained in the American Standard Graphical Symbols for Electrical Power and Control, Z32.3-1946, and for Telephone, Telegraph and Radio Use, Z32.5-1944.

The American Institute of Electrical Engineers and the American Society of Mechanical Engineers were sponsors of the new standard, which contains 81 sections covering symbols for almost all electrical engineering work in the fields of power and communication. Sample diagrams show the use of the single line drawing in illustrations of a laboratory sound system, a microwave test setup telephone repeater and line equipment, and power equipment.

Test films are the customary tool for checking picture and sound performance in theaters, service shops, in factories and in television stations. Twenty-seven different test films in 16mm and 35mm sizes are produced by the Society and the Motion Picture Research Council. Write to Society Headquarters for a free catalog.

Six American Standards have been added to the Motion Picture Set of 60 which the Society has had available for sale. To holders of the present set the Society has made available the six new standards: PH22.11-1952, PH22.24-1952, PH22.73-1951, PH22.74-1951, PH22.76-1951 and PH22.82-1951. The price is $1 plus 3% sales tax on deliveries in New York City.

The new set of 66 standards in a heavy three-post binder with an index is available at $14.50 plus 3% sales tax on deliveries in New York City; foreign postage is $.50 extra.

All standards **in sets only** are available from Society Headquarters. Single copies of any particular standard must be ordered from the American Standards Association, 70 East 45th St., New York 17, N.Y.

New Members

The following members have been added to the Society's rolls since those last published. The designations of grades are the same as those used in the 1950 MEMBERSHIP DIRECTORY.

Honorary (**H**) Fellow (**F**) Active (**M**) Associate (**A**) Student (**S**)

Angarola, Salvatore, SRT—TV Studios. **Mail:** 90-50—53 Ave., Elmhurst, L.I., N.Y. (**S**)

Arora, O. P., University of Southern California. **Mail:** 1183½ W. 29 St., Los Angeles 7, Calif. (**S**)

Bartleson, C. James, Jr., Photographic Color Technician, Pavelle Color, Inc. **Mail:** 7018 Colonial Rd., Brooklyn, N.Y. (**A**)

Booth, John H. L., University of Southern California. **Mail:** Ste. C, 2730 S. Normandie, Los Angeles 7, Calif. (**S**)

Bray, Frederic L., Engineer, Du-Art Film Laboratories. **Mail:** 353 Pin Oak La., Westbury, L.I., N.Y. (**A**)

Catanzaro, Carl J., SRT—TV Studios. **Mail:** 27-19—24 Ave., Astoria, L.I., N.Y. (**S**)

Colman, Robert, University of Southern California. **Mail:** 1732¼ W. 20 St., Los Angeles, Calif. (**S**)

Deutch, Irving, New Inst. for Film & Television. **Mail:** 2110 Newkirk Ave., Brooklyn, N.Y. (**S**)

Dickinson, William A., Electronics Engineer, Sylvania Electric Products, Inc., Seneca Falls, N.Y. (**M**)

Doba, Stephen, Jr., Telephone Engineer, Bell Telephone Laboratories, Inc., Murray Hill, N.J. (**A**)

Erlinger, Joseph A., Foreman, Camera Shop, Warner Brothers. **Mail:** 1212 S. Crescent Heights Blvd., Los Angeles 35, Calif. (**A**)

Everest, F. Alton, Associate Director, Moody Institute of Science. **Mail:** 11428 Santa Monica Blvd., Los Angeles 25, Calif. (**A**)

Goren, Lewis, SRT—TV Studios. **Mail:** 124 E. 146 St., New York 51, N.Y. (**S**)

Gregory, John R., New Institute for Motion Pictures. **Mail:** 64–12—65 Pl., Middle Village 79, N.Y. (**S**)

Hall, Frank, Clinical-Surgical Photographer, Dept. of Veterans Affairs, Sunnybrook Hospital. **Mail:** 1068 St. Clair Ave., W., Toronto, Ont., Canada. (**A**)

Hanson, Charles L., Jr., Photographic Technician, Arthur D. Little, Inc. **Mail:** 54 Hammond St., Cambridge 38, Mass. (**A**)

Harber, Richard G., University of Southern California. **Mail:** 7843 Flight Ave., Los Angeles 45, Calif. (**S**)

Hollzer, Herbert M., University of Southern California. **Mail:** 820 S. Mansfield, Los Angeles 36, Calif. (**S**)

Howland, Walter A., Optical Engineer, J. A. Maurer, Inc. **Mail:** 179 Sadler Rd., Bloomfield, N.J. (**A**)

Jacobsen, Michael M., Sound Engineer, A/S Palladium Film. **Mail:** Gustav Adolfs Gade 5, Copenhagen Ø, Denmark. (**A**)

Jamieson, Hugh V., Jr., Production Manager, Partner, Jamieson Film Co. **Mail:** 3825 Bryan, Dallas, Tex. (**M**)

Kayser, Paul W., Foreign Manager, Westrex Corp. **Mail:** 299 S. Middletown Rd., Pearl River, N.Y. (**A**)

Kirk, Michael, Film Editor, WOSM-TV. **Mail:** 2139 Gen. Taylor, New Orleans 15, La. (**M**)

Linton, C. Bruce, University of Southern California. **Mail:** 401 Adlena Dr., Fullerton, Calif. (**S**)

Long, Maurice L., University of Southern California. **Mail:** 3202 W. 43 Pl., Los Angeles 8, Calif. (**S**)

MacIsaac, Donald M., Sound Editor, Syracuse University, Audio-Visual Center. **Mail:** 304 Farmer St., Syracuse, N.Y. (**A**)

Madore, Douglas, Actor, Director, Freelance. **Mail:** 6088 Selma Ave., Hollywood 28, Calif. (**S**)

Mell, Labe B., General Manager, Reela Films, Inc., 17 N.W. Third St., Miami, Fla. (**A**)

Mendelwager, Jerome, SRT—TVStudios. **Mail:** 1016 Boulevard, Bayonne, N.J. (**S**)

Nesbitt, Charles D., Motion Picture Technical Representative, E. I. du Pont de Nemours & Co. **Mail:** 3289 N. California Ave., Chicago, Ill. (**M**)

Netervala, Minoo, University of Southern California. **Mail:** 1190 W. Adams Blvd., Los Angeles 7, Calif. (**S**)

Noriega, Joseph, Motion Picture Producer, Reforma 77, Apt. 1107, Mexico City, Mexico. (**M**)

Oleson, Robert, University of Southern California. **Mail:** 207½ S. Hoover, Los Angeles, Calif. (**S**)

Pascal, Captain Samuel, Hq. Sqd., 131 A.B. Gp., George Air Force Base, Victorville, Calif. (**A**)

Patelis, George, SRT—TV Studios. **Mail:** 87–72—253 St., Bellerose, N.Y. (**S**)

Pritzlaff, Kipp, University of Southern California. **Mail:** 14340 Dickens, Sherman Oaks, Calif. **(S)**

Quiroga, Alex S., TV Engineer, ABC-TV. **Mail:** 3757½ Monon St., Hollywood, Calif. **(M)**

South, David F. W., University of Southern California. **Mail:** 5353 W. Third St., The Art Center School, Los Angeles, Calif. **(S)**

Swenson, Russell, University of Southern California. **Mail:** 682 W. 35 St., Los Angeles 7, Calif. **(S)**

Ward, Julius C., Electronic Engineer, General Precision Laboratory, 7 Manville La., Pleasantville, N.Y. **(A)**

Wheeler, Charles F., Assistant Cameraman, Free-lance. **Mail:** 2557 Westwood Blvd., Los Angeles 64, Calif. **(A)**

Wilt, Chester, Development Engineer, Eastman Kodak Co. **Mail:** 4007 St. Paul Blvd., Rochester 17, N.Y. **(A)**

Win, Maung Nay, University of Southern California. **Mail:** 1130 W. 37 St., Los Angeles, Calif. **(S)**

Wong, Willie, SRT—TV Studios. **Mail:** 66 Cedar Dr., Farmingdale, N.Y. **(S)**

CHANGES IN GRADE

Bauman, Harold W., (A) to **(M)**
Demetros, Nicholas K., (A) to **(M)**
Duvall, Delmer P., (A) to **(M)**
Gemeinhardt, George C., (A) to **(M)**
Gillet, Albert, (A) to **(M)**
Helhena, Leslie E., (A) to **(M)**
Kemp, Jay S., (A) to **(M)**
Krulish, John A., (A) to **(M)**
Manley, Fred A., (A) to **(M)**
McGough, William A., (A) to **(M)**
Newmayer, Richard H., (A) to **(M)**
Pittaro, Ernest M., (A) to **(M)**
Schwarz, Sigmund, (A) to **(M)**
Searle, Milton H., (A) to **(M)**
Smith, H. Beresford, (A) to **(M)**
Sparks, R. F., (A) to **(M)**
Szeglin, Stephen J., (A) to **(M)**
Wesson, Rufus, (A) to **(M)**

Meetings

The Atlantic Coast Section of the SMPTE will meet on April 16, 7:30 P.M., at the Henry Hudson Hotel, New York City, when Robert Dressler of Paramount Pictures Corp.'s Chromatic Television Laboratories will present a paper and a demonstration on electrooptic sound recording on film.

71st Semiannual Convention of the SMPTE, April 21–25, The Drake, Chicago

Other Societies

American Physical Society, May 1–3, Washington, D.C.

Acoustical Society of America, May 8–10, New York

Society of Photographic Engineers, Symposium on Instrumentation, June 4–5, Naval Ordnance Laboratory, White Oak, Md.

American Institute of Electrical Engineers, Summer General Meeting, June 23–27, Hotel Nicollet, Minneapolis, Minn.

American Physical Society, June 30–July 3, Denver, Colo.

National Audio-Visual Association, Convention and Trade Show, Aug. 2–5, Hotel Sherman, Chicago

Photographic Society of America, Annual Convention, Aug. 12–16, Hotel New Yorker, New York

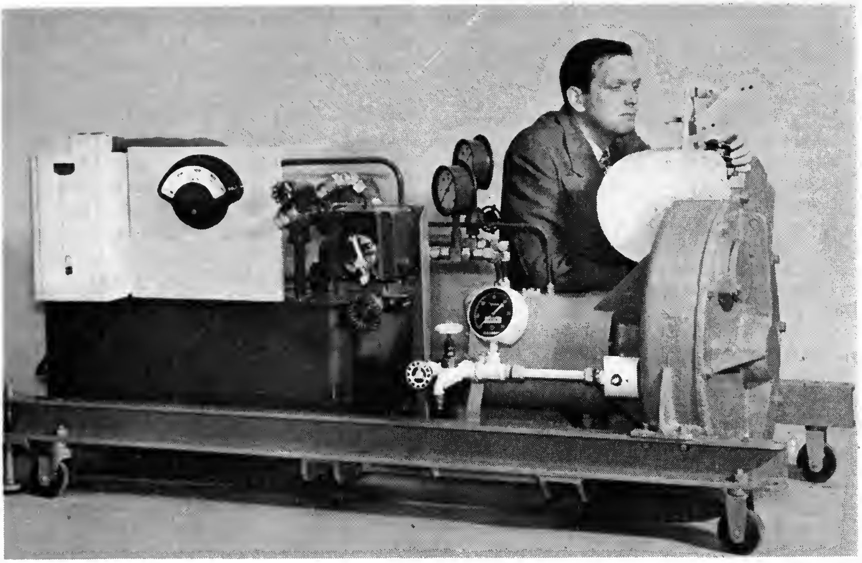
American Institute of Electrical Engineers, Pacific General Meeting, Aug. 19–22, Hotel Westward Ho, Phoenix, Ariz.

Illuminating Engineering Society, National Technical Conference, Aug. 27–30, Washington, D.C.

International Society of Photogrammetry, Conference, Sept. 4–13, Hotel Shoreham, Washington, D.C.

New Products

Further information about these items can be obtained direct from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of these items does not constitute endorsement of the products.



A new ultra-high-speed camera, designed to take pictures at speeds up to 100,000 frames/sec, has been developed at Battelle Institute, Columbus, Ohio. It will be described by C. D. Miller of the Battelle technical staff in a paper to be presented before an early convention of SMPTE. The camera is an extensively modified version of one developed by Mr. Miller some years ago while employed by the National Advisory Committee for Aeronautics. The earlier camera was described in the November 1949 *Journal* and in the reprint, *High-Speed Photography*, Vol. 2.

The new camera is being used at Battelle in studies of knock in spark-ignited piston engines, and will be available for other high-speed research at Battelle as desired by industry or government. The camera operates under conditions of steady light, with direct photography, Schlieren photography or shadowgraphs. It operates by optical compensation, exposes six feet of standard 8-mm film in a single burst, with resolution reported better than 30 lines per millimeter. Exposed film is ready for projection as a motion picture immediately after development, without the need of a reprinting and registering procedure.

Back issues of the Journal available: The following Volumes are available upon a reasonable offer to Alfred S. Norbury, 3526 Harrison St., Kansas City 3, Mo.

Vol. 44 (Jan.-June 1945)
Vol. 45 (July-Dec. 1945)
Vol. 47 (July-Dec. 1946)
Vol. 48 (Jan.-June 1947)
Vol. 49 (July-Dec. 1947)
Vol. 50 (Jan.-June 1948)
Vol. 51 (July-Dec. 1948)
Vol. 52 (Jan.-June 1949)
Vol. 56 (Jan.-June 1951)
Vol. 57 (July-Dec. 1951)

A Silent Magnetic Splicer has been developed and patented by Unusual Films at Bob Jones University in Greenville, S.C., which says that it is for the fast and durable splicing of magnetic film. A diagonal butt splice with Minnesota Mining and Manufacturing Tape No. 41 that will outlast normal film has been achieved. A single frame can be removed and restored; a splice made in this manner can be broken and put together again without loss of a frame; and trims and waste material can be reclaimed and used repeatedly until too short to be of any value. Designed specifically for magnetic film in accordance with existing film standards, the Silent Splicer needs no blooping. While there is some disadvantage, the University says, in not being able to see the striations, with a little practice and familiarization with a sound reader one can locate sync closer than half a frame. Film must be handled carefully and all heads must be demagnetized regularly, if clear sound is to be maintained.

The Sound Splicer is designed so that one side of the machine is for cutting of film, the other side for registration, perforation and application of the tape. It is available for 16mm film either double or single perforated.

"Common Causes of Damage to 35mm Release Prints" has just been issued in an extensively revised edition by the Eastman Kodak Company as a means of helping laboratories, exchanges, and theaters to keep motion picture release prints in better condition.

The booklet discusses such possible sources of damage as failure to provide adequate storage facilities, improper laboratory methods, inadequate inspection in the exchanges, careless handling in the projection room and worn or imperfectly adjusted projectors. Also covered are such general but equally important subjects as making good splices, methods of lubrication of release prints, directions for determining the correct tension of projector parts, and methods of making other simple projector adjustments.

Some of the material that appears in this new data book has been issued by Kodak in previous booklets covering the same general field, but all of the old material has now been brought up to date and a discussion of how properly to identify the new safety base material now used for release prints has also been added.

Written in four sections—the film, the processing laboratory, the exchange and the theater—and liberally illustrated with many comparison photographs, "Common Causes of Damage to 35mm Release Prints" can be obtained without charge on request to the Motion Picture Division, Eastman Kodak Company. The data book is punched for binding in the *Kodak Photographic Notebook.*

Position Wanted

Sound mixer and transmission engineer: 5 yr experience 35mm magnetic and optical, 16mm optical and disc recording systems. As mixer has experience stage recording and re-recording; in transmission has installed a recording channel complete from design to operation, also maintenance. Will accept position any geographic location. Write L-30, c/o Fifer, 143 Church St., Phoenixville, Pa.

Committees of the Society

As of March 15, 1952

Administrative Committees

ADMISSIONS. *To pass upon all applications for membership, applications for transfer, and to review the Student and Associate membership list periodically for possible transfer to the Associate and Active grades, respectively. The duties of each committee are limited to applications and transfers originating in the geographic area covered.*

E. A. Bertram, *Chairman, East,* DeLuxe Laboratories, 850 Tenth Ave., New York 19, N.Y.

C. R. Keith — W. B. Lodge — L. A. Bonn

Bertel J. Kleerup, *Chairman, Central,* Society for Visual Education, 1345 W. Diversey Parkway, Chicago 14, Ill.

E. E. Bickel — Lloyd Thompson — M. G. Townsley

N. L. Simmons, *Chairman, West,* Eastman Kodak Co., 6706 Santa Monica Blvd., Hollywood 38, Calif.

T. T. Moulton — E. H. Reichard — Petro Vlahos

BOARD OF EDITORS. *To pass upon the suitability of all material submitted for publication, or for presentation at conventions, and publish the* JOURNAL.

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EUROPEAN ADVISORY COMMITTEES. *To act as liaison between the general Society and European firms, individuals, and organizations interested in motion picture and television engineering. To report to the Society on such affairs in Europe, on new technical developments, and to assist the Papers Committee in soliciting papers for publication in the* JOURNAL.

I. D. Wratten, *Chairman (British Division),* Kodak, Ltd., Kingsway, London, England

R. H. Cricks — W. M. Harcourt — L. Knopp — A. W. Watkins

L. Didiée, *Chairman (Continental Division),* Association Francaise des Ingénieurs et Techniciens du Cinéma, 92 Champs-Elysées, Paris (8e), France

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R. Bocquel	S. Feldman	M. Terrus	M. Yvonnet
M. Certes	J. Fourrage		

FELLOW AWARD. *To consider publications of Active members as candidates for elevation to Fellow, and to submit such nominations to the Board of Governors.*

Earl I. Sponable, *Chairman,* Movietonews, Inc., 460 W. 54 St., New York 19, N. Y.

Herbert Barnett	R. M. Corbin	Barton Kreuzer	V. C. Shaner
F. T. Bowditch	J. G. Frayne	W. C. Kunzmann	E. M. Stifle
F. E. Cahill	C. E. Heppberger	Peter Mole	

HISTORICAL AND MUSEUM. *To collect facts and assemble data relating to the historical development of the motion picture and television industries, to encourage pioneers to place their work on record in the form of papers for publication in the* Journal, *and to place in suitable depositories equipment pertaining to the industry.*

E. A. Bertram, *Chairman,* DeLuxe Laboratories, Inc., 850 Tenth Ave., New York 19, N.Y.

(Under Organization)

HONORARY MEMBERSHIP. *To search diligently for candidates who through their basic inventions or outstanding accomplishments have contributed to the advancement of the motion picture industry and are thus worthy of becoming Honorary members of the Society.*

Gordon Chambers, *Chairman,* Eastman Kodak Co., 343 State St., Rochester 4, N.Y.

Carroll H. Dunning	Philo T. Farnsworth	Barton Kreuzer	Loren L. Ryder

JOURNAL AWARD. *To recommend to the Board of Governors the author or authors of the most outstanding paper originally published in the* Journal *during the preceding calendar year to receive the Society's Journal Award.*

F. J. Kolb, Jr., *Chairman,* Eastman Kodak Co., 343 State St., Rochester 4, N.Y.

Paul Arnold	A. N. Goldsmith	Joseph H. Spray

MEMBERSHIP. *To solicit new members and to arouse general interest in the activities of the Society and its publications.*

A. Raymond Gallo, *General Chairman,* Quigley Publications, 1270 Sixth Ave., New York 20, N.Y.

J. B. McCullough, *Vice-Chairman,* Motion Picture Association, 28 W. 44th St., New York 18, N.Y.

Col. Samuel R. Todd, *Vice-Chairman,* Bureau of Electrical Inspection, Room 707, City Hall, Chicago 2, Ill.

L. D. Grignon, *Vice-Chairman,* Twentieth Century-Fox, Box 900, Beverly Hills, Calif.
Don Prideaux, Lamp Department, General Electric Company, 601 W. Fifth St., Los Angeles 13, Calif.
John W. Duvall, E. I. du Pont de Nemours & Co., 6656 Santa Monica Blvd., Hollywood 38, Calif.
H. S. Walker, *Chairman,* 4040 St. Catherine St., W., Montreal, Quebec.

(Under Organization)

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J. W. Cummings	Bruce Howard	J. A. Ouimet	
C. R. Daily	B. J. Howell	G. F. Rackett	
A. R. Davis	Hugh Jamieson	J. W. Servies	

NOMINATIONS. *To recommend nominations to the Board of Governors for annual election of officers and governors.*

Earl I. Sponable, *Chairman,* Movietonews, Inc., 460 W. 54 St., New York 19

F. T. Bowditch	N. D. Golden	J. K. Hilliard	C. H. Percy
G. L. Carrington	D. E. Hyndman	F. E. Cahill	R. C. Warn

PAPERS. *To solicit papers and provide the program for semiannual conventions, and make available to local sections for their meetings papers presented at national conventions.*

Edward S. Seeley, *Chairman*, Altec Service, 161 Sixth Ave., New York 13, N.Y.

Joseph E. Aiken, *Vice-Chairman*, 116 No. Galveston St., Arlington, Va.

F. G. Albin, *Vice-Chairman*, American Broadcasting Co., Station KECA-TV, 4151 Prospect Ave., Hollywood, Calif.

G. G. Graham, *Vice-Chairman*, National Film Board of Canada, John St., Ottawa, Canada

W. H. Rivers, *Vice-Chairman*, Eastman Kodak Co., 342 Madison Ave., New York 17, N.Y.

G. W. Colburn, *Vice-Chairman*, 164 N. Wacker Dr., Chicago 6, Ill.

John H. Waddell, *Vice-Chairman*, Wollensak Optical Co., 850 Hudson Ave., Rochester, N.Y.

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A. C. Blaney	W. P. Dutton	P. A. Jacobson	Ben Plakun
Richard Blount	Farciot Edouart	William Kelley	Edward Schmidt
R. P. Burns	F. L. Eich	George Lewin	N. L. Simmons
Philip Caldwell	Charles Handley	E. C. Manderfeld	S. P. Solow
F. O. Calvin	R. N. Harmon	Glenn Matthews	J. G. Stott
J. P. Corcoran	Scott Helt	Pierre Mertz	W. L. Tesch
P. M. Cowett	C. E. Heppberger	Harry Milholland	S. R. Todd
G. R. Crane	J. K. Hilliard	W. J. Morlock	M. G. Townsley

PROGRESS. *To prepare an annual report on progress in the motion picture and television industries.*

C. W. Handley, *Chairman*, 1960 West 84 St., Los Angeles 44, Calif.

J. E. Aiken	T. J. Gibbons	W. F. Kelley	B. F. Perry
W. L. Bell	G. H. Gordon	R. E. Lewis	E. H. Reichard
P. G. Caldwell	G. R. Groves	W. A. Mueller	W. L. Tesch
J. W. Duvall			

PROGRESS MEDAL AWARD. *To recommend to the Board of Governors a candidate who by his inventions, research, or development has contributed in a significant manner to the advancement of motion picture technology, and is deemed worthy of receiving the Progress Medal Award of the Society.*

David B. Joy, *Chairman*, National Carbon Division, 30 E. 42 St., New York 17, N.Y.

Max Batsel	F. H. McIntosh	G. H. Mitchell	D. R. White

DAVID SARNOFF AWARD. *To recommend to the Board of Governors a candidate who has done outstanding work in some technical phase of the broad field of television or in any similar phase of theater television, whether in research, development design, manufacture or operation.*

Pierre Mertz, *Chairman*, Bell Telephone Laboratories, Inc., 463 West, St. New York 14, N.Y.

R. L. Garman	T. T. Goldsmith	O. B. Hanson	W. B. Lodge

SUSTAINING MEMBERSHIP. *To solicit new sustaining members and thereby obtain adequate financial support required by the Society to carry on its technical and engineering activities.*

Earl I. Sponable, *Chairman*, Movietonews, Inc., 460 W. 54 St., New York 19, N.Y.

D. B. Joy	S. P. Solow

SAMUEL L. WARNER AWARD. *To recommend to the Board of Governors a candidate who has done the most outstanding work in the field of sound motion picture engineering, in the development of new and improved methods or apparatus designed for sound motion pictures, including any steps in the process, and who, whether or not a Member of the Society of Motion Picture and Television Engineers, is deemed eligible to receive the Samuel L. Warner Memorial Award of the Society*

Glenn L. Dimmick, *Chairman*, RCA Victor Division, Front and Cooper Sts., Camden, N.J.

Lloyd Goldsmith	John Hilliard	John Maurer	Otto Sandvik

Engineering Committees

COLOR. *To make recommendations and prepare specifications for the operation, maintenance, and servicing of color motion picture processes, accessory equipment, studio lighting, selection of studio set colors, color cameras, color motion picture films, and general color photography.* (*File C 1*)

H. H. Duerr, *Chairman*, Ansco, Binghamton, N.Y.

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H. E. Bragg	R. M. Evans	W. W. Lozier	G. F. Rackett
O. O. Ceccarini	J. G. Frayne	A. J. Miller	L. E. Varden
R. O. Drew	L. T. Goldsmith	C. F. J. Overhage	J. P. Weiss

FILM DIMENSIONS. *To make recommendations and prepare specifications on those film dimensions which affect performance and interchangeability, and to investigate new methods of cutting and perforating motion picture film in addition to the study of its physical properties.* (*File FD 2*)

E. K. Carver, *Chairman*, Eastman Kodak Co., Kodak Park Works, Rochester 4, N.Y.

J. E. Aiken	W. G. Hill	N. L. Simmons	W. J. Wade
E. A. Bertram	A. J. Miller	M. G. Townsley	D. R. White
A. M. Gundelfinger	W. E. Pohl		

FILM-PROJECTION PRACTICE. *To make recommendations and prepare specifications for the operation, maintenance, and servicing of motion picture projection equipment, projection rooms, film-storage facilities, stage arrangement, screen dimensions and placement, and maintenance of loudspeakers to improve the quality of reproduced sound and the quality of the projected picture in the theater.* (*File FPP 3*)

R. H. Heacock, *Chairman*, Radio Corporation of America, RCA Victor Div., Camden 2, N.J.

C. S. Ashcraft	H. F. Heidegger	M. D. O'Brien	Ben Schlanger
F. E. Cahill	C. F. Horstman	Paul Ries	J. W. Servies
L. W. Davee	H. T. Matthews	Harry Rubin	S. R. Todd

FILMS FOR TELEVISION. *To make recommendations and prepare specifications on all phases of the production, processing and use of film made for transmission over a television system excluding video transcriptions.* (*File FTV 4*)

R. L. Garman, *Chairman*, General Precision Laboratory, Inc., 63 Bedford Road, Pleasantville, N.Y.

R. O. Drew	Pierre Mertz	R. C. Rheineck	C. L. Townsend
Richard Hodgson	H. C. Milholland	H. J. Schlafly	L. F. Transue
S. E. Howse	G. C. Misener	N. L. Simmons	T. G. Veal
R. Johnston	R. M. Morris	J. G. Stott	H. E. White
H. R. Lipman			

HIGH-SPEED PHOTOGRAPHY. *To make recommendations and prepare specifications for the construction, installation, operation, and servicing of equipment for photographing and projecting pictures taken at high repetition rates or with extremely short exposure times.* (*File HSP 5*)

H. E. Edgerton, *Chairman*, Dept. of Electrical Engineering, Massachusetts Institute of Technology, Cambridge 39, Mass.

Richard O. Painter, *Vice-Chairman*, General Motors, Proving Ground Section, Milford, Mich.

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H. C. Barr	Eleanor Gerlach	D. H. Peterson	J. H. Waddell
D. M. Beard	C. D. Miller	Earl Quinn	Roy Wolford
C. S. Braser	Eugene Miller	M. L. Sandell	C. W. Wyckoff
F. E. Carlson	Kenneth Morgan	Kenneth Shaftan	

LABORATORY PRACTICE. *To make recommendations and prepare specifications for the operation, maintenance, and servicing of motion picture printers, processing machines, inspection projectors, splicing machines, film-cleaning and treating equipment, rewinding equipment, any type of film-handling accessories, methods, and processes which offer increased efficiency and improvements in the photographic quality of the final print.* (*File LP 6*)

J. G. Stott, *Chairman*, Du Art Film Laboratories, 245 West 55 St., New York, N.Y.

V. D. Armstrong
H. L. Baumbach
D. P. Boyle
O. E. Cantor
Gordon Chambers
G. W. Colburn
I. M. Ewig
T. M. Ingman
P. A. Kaufman
C. F. LoBalbo
J. A. Maurer
O. W. Murray
W. H. Offenhauser
W. E. Pohl
E. H. Reichard
V. C. Shaner
J. H. Spray
Lloyd Thompson
Paul Zeff

MOTION PICTURE STUDIO LIGHTING AND PROCESS PHOTOGRAPHY. *To make recommendations and prepare specifications for the operation, maintenance, and servicing of all types of studio and outdoor auxiliary lighting equipment, tungsten light and carbon-arc sources, lighting-effect devices, diffusers, special light screens, etc., to increase the general engineering knowledge of the art; and to make recommendations and prepare specifications on motion picture optical printers, process projectors (background process), matte processes, special process lighting technique, special processing machines, miniature-set requirements, special-effects devices, and the like, that will lead to improvement in this phase of the production art.* (*File MPSL 7*)

J. W. Boyle, *Chairman*, 139½ South Doheny Dr., Los Angeles 48, Calif.

Richard Blount
Karl Freund
C. W. Handley
M. A. Hankins
C. R. Long
W. W. Lozier
D. W. Prideaux
Petro Vlahos

OPTICS. *To make recommendations and prepare specifications on all subjects connected with lenses and their properties.* (*File Op 8*)

R. Kingslake, *Chairman*, Eastman Kodak Co., Hawk Eye Works, Rochester 4, N.Y.

F. G. Back
A. A. Cook
C. R. Daily
I. C. Gardner
J. W. Gillon
Grover Laube
J. L. Maulbetsch
J. A. Maurer
G. A. Mitchell
A. E. Murray
W. E. Pohl
L. T. Sachtleben
O. H. Schade
M. G. Townsley

SCREEN BRIGHTNESS. *To make recommendations, prepare specifications, and test methods for determining and standardizing the brightness of the motion picture screen image at various parts of the screen, and for special means or devices in the projection room adapted to the control or improvement of screen brightness.* (*File SB 10*)

W. W. Lozier, *Chairman*, National Carbon Div., Fostoria, Ohio

H. J. Benham
F. E. Carlson
M. H. Chamberlin
E. R. Geib
L. D. Grignon
A. J. Hatch
L. B. Isaac
W. F. Kelley
F. J. Kolb
L. J. Patton
O. W. Richards
Leonard Satz
Ben Schlanger
Allen Stimson
C. R. Underhill
G. H. Walter
H. E. White
A. T. Williams
D. L. Williams

16MM AND 8MM MOTION PICTURES. *To make recommendations and prepare specifications for 16mm and 8mm cameras, 16mm sound recorders and sound-recording practices, 16mm and 8mm printers and other film laboratory equipment and practices, 16mm and 8mm projectors, splicing machines, screen dimensions and placement, loudspeaker output and placement, preview or theater arrangements, test films, and the like, which will improve the quality of 16mm and 8mm motion pictures.* (*File SE 11*)

M. G. Townsley, *Chairman*, Bell & Howell Co., 7100 McCormick Rd., Chicago 45, Ill.

H. W. Bauman
W. C. Bowen
F. L. Brethauer
F. E. Brooker
F. E. Carlson
Carl Claras
E. W. D'Arcy
G. A. del Valle
J. W. Evans
C. R. Fordyce
John Forrest
R. C. Holslag
H. J. Hood
W. W. Lozier
D. F. Lyman
W. C. Miller
J. W. Moore
W. H. Offenhauser
A. G. Petrasek
L. T. Sachtleben
H. H. Strong
Lloyd Thompson
Willett Wilson

SOUND. *To make recommendations and prepare specifications for the operation, maintenance, and servicing of motion picture film, sound recorders, re-recorders, and reproducing equipment, methods of recording sound, sound-film processing, and the like, to obtain means of standardizing procedures that will result in the production of better uniform quality sound in the theater. (File So 12)*

J. K. Hilliard, *Chairman*, Altec Lansing Corp., 9356 Santa Monica Blvd., Beverly Hills, Calif.

G. L. Dimmick, *Vice-Chairman*, RCA Victor Division, Camden. N.J.

F. G. Albin	E. W. D'Arcy	J. P. Livadary	G. E. Sawyer
H. W. Bauman	R. J. Engler	J. A. Maurer	W. L. Thayer
R. J. Beaudry	R. M. Fraser	K. M. MacIlvain	M. G. Townsley
A. C. Blaney	J. G. Frayne	W. C. Miller	Harold Walker
D. J. Bloomberg	L. T. Goldsmith	G. C. Misener	J. P. Weiss
Harry Brueggemann	L. D. Grignon	Otto Sandvik	W. W. Wetzel
F. E. Cahill			

STANDARDS. *To survey constantly all engineering phases of motion picture production, distribution, and exhibition, to make recommendations and prepare specifications that may become proposals for American Standards. This Committee should follow carefully the work of all other committees on engineering and may request any committee to investigate and prepare a report on the phase of motion picture engineering to which it is assigned. (File St 13)*

H. J. Hood, *Chairman*, Eastman Kodak Co., 343 State St., Rochester 4, N.Y.

Chairmen of Engineering Committees

G. L. Beers	E. C. Fritts	J. K. Hilliard	F. J. Pfeiff
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E. K. Carver	R. H. Heacock	J. A. Norling	M. G. Townsley
H. E. Edgerton			

Members at Large

F. E. Carlson	W. F. Kelley	J. A. Maurer	D. R. White

STEREOSCOPIC MOTION PICTURES. *(File STE 20)*

J. A. Norling, *Chairman*, Loucks and Norling Studios, Inc., 245 West 55 St., New York 19, N.Y.

G. A. Chambers	Clarence Kennedy	K. Pestrecov	J. T. Rule
J. S. Goldhammer	Joseph Mahler	F. A. Ramsdell	W. H. Ryan
Gerald Graham	Wil Marcus	J. A. Ruddy	R. J. Spottiswoode
L. B. Isaac			

TELEVISION FILM EQUIPMENT (JOINT RTMA-SMPTE COMMITTEE). *To make recommendations and prepare specifications on all phases of film equipment as used in the television broadcast stations. (File TVFE 14)*

F. N. Gillette, *RTMA*, *Chairman*, General Precision Laboratory, 63 Bedford Road, Pleasantville, N.Y.

E. C. Fritts, *SMPTE*, *Vice-Chairman*, Eastman Kodak Co., 343 State St., Rochester 4, N.Y.

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A. J. Baracket	E. C. Manderfeld	R. M. Morris	C.L. Townsend
P. F. Brown	J. A. Maurer	N. F. Oakley	M. G. Townsley
Sydney Cramer	H. C. Milholland	R. C. Rheineck	H. E. White

TELEVISION STUDIO LIGHTING. *To make recommendations and prepare specifications on all phases of lighting employed in television studios. (File TVSL 15)*

Richard Blount, *Chairman*, General Electric Co., Nela Park, Cleveland 12, Ohio

H. R. Bell	Otis Freeman	R. S. O'Brien	Malcolm Waring
A. H. Brolly	H. M. Gurin	Newland Smith	W. R. Wilson
D. D. Cavelli	Robert Morris	Adrian Terlouw	

TEST FILM QUALITY. *To develop and keep up to date all test film specifications, and to supervise, inspect and approve methods of production and quality control of all test films sold by the Society.* (*File TFQ 16*)

F. J. Pfeiff, *Chairman*, Altec Service Corp.. 161 Sixth Ave., New York 13, N.Y.

R. M. Corbin
Russell Drew
W. F. Kelley
J. A. Maurer
Joseph Spray
J. G. Stott
M. G. Townsley

THEATER TELEVISION. *To make recommendations and prepare specifications for the construction, installation, operation, maintenance, and servicing of equipment for projecting television pictures in the motion picture theater, as well as projection-room arrangements necessary for such equipment, and such picture-dimensional and screen-characteristic matters as may be involved in high-quality theater-television presentations.* (*File TTV 17*)

G. L. Beers, *Chairman*, Radio Corporation of America, RCA Victor Div., Camden, N.J.

Ralph Austrian
F. E. Cahill
R. L. Garman
E. P. Genock
A. N. Goldsmith
E. D. Goodale
N. L. Halpern
Richard Hodgson
C. F. Horstman
D. E. Hyndman
L. B. Isaac
A. G. Jensen
P. J. Larsen
W. W. Lozier
R. H. McCullough
G. C. Misener
Harry Rubin
L. L. Ryder
Otto Sandvik
Ed Schmidt
A. G. Smith
E. I. Sponable
J. E. Volkmann

THEATER ENGINEERING. *To make recommendations and prepare specifications of engineering methods and equipment of motion picture theaters in relation to their contribution to the physical comfort and safety of patrons, so far as can be enhanced by correct theater design, construction, and operation of equipment.* (*File TE 18*)

J. W. Servies, *Chairman*, National Theatre Supply, 92 Gold St., New York 7, N.Y.

F. W. Alexa
Henry Anderson
Charles Bachman
E. J. Content
C. M. Cutler
James Frank
Aaron Nadell
E. H. Perkins
L. E. Pope
Leonard Satz
Ben Schlanger
Seymour Seider
J. E. Troy
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Techniques for Effective High-Speed Photography and Analysis

By RICHARD O. PAINTER

High-speed photographic methods used with commercially available moving film cameras are reviewed in this paper. Careful planning in regard to field size, reference lines, background and timing as well as other factors can contribute a great deal toward producing films which furnish a maximum of useful information. Special techniques employed in analysis can likewise simplify the task of data reduction. Some of these methods are illustrated.

HIGH-SPEED PHOTOGRAPHY has been used as an engineering tool by General Motors Proving Ground for over thirteen years. The experience gained during this period has been almost entirely with commercially available rotating-prism cameras covering the speed range from about 150 to 15,000 pictures per second. In a corporation as huge as General Motors and with such diversified products, the range of subjects to which high-speed photography might be applied is naturally very large. Much has been written concerning specialized techniques for high-speed photography such as schlieren, shadowgraph, X-ray and others. I shall not dwell on elaborate techniques such as these, but will relate some of the more common problems faced in the application of high-speed photography and how in our experience these problems have been met.

A 16mm camera with a maximum speed of about 2000 pictures per second was used for our early high-speed photographic work. Our lighting equipment consisted only of conventional photoflood lamps in aluminum reflectors. There was only one exposure procedure to follow when using higher camera speeds: "Open the lens fully, use as many lights as space permits, and bring them as close to the subject as possible." It was obvious that room for improvement existed in the lighting equipment. When projector spotlights first became available we were quick to make use of them. Overvoltage for these units was obtained through autotransformer boxes provided with a switch for selecting line voltage or high voltage, a tap switch for adjusting the high-voltage output in 10-v steps and a meter for reading the output voltage to the lights. These units and the projector spotlights were the solution to the lighting problem and are in fact still in use for most of our work. They are especially handy in compensating for line voltages that may be higher or lower than normal and are now provided with relays for shunting the line switch and throwing the lights on and off simultaneously with the camera operation. Experience has shown that the light intensity builds up rapidly enough to give adequate exposure from the very start of the film.

Presented on October 16, 1951, at the Society's Convention at Hollywood, Calif., by Richard O. Painter, General Motors Proving Ground, Milford, Mich.

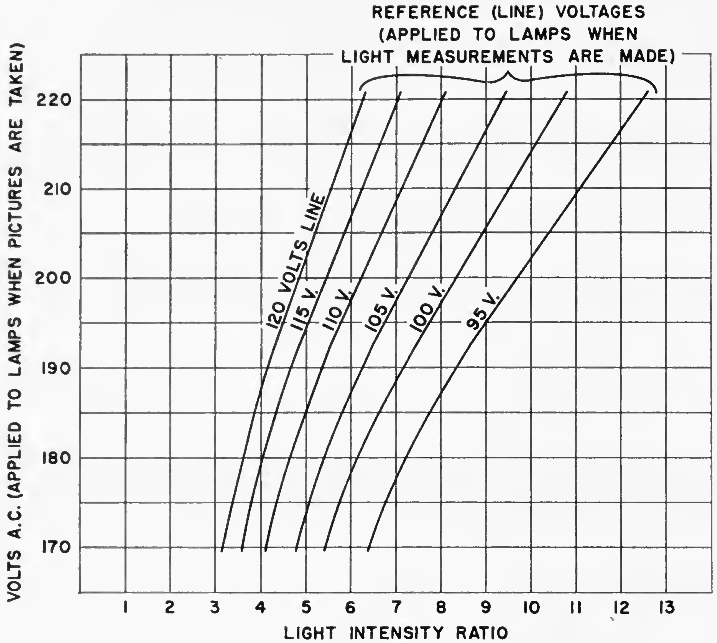

Fig. 1. Light intensity ratios for projector spotlights, G.E. Type Par/SP-150-w, 120-v.

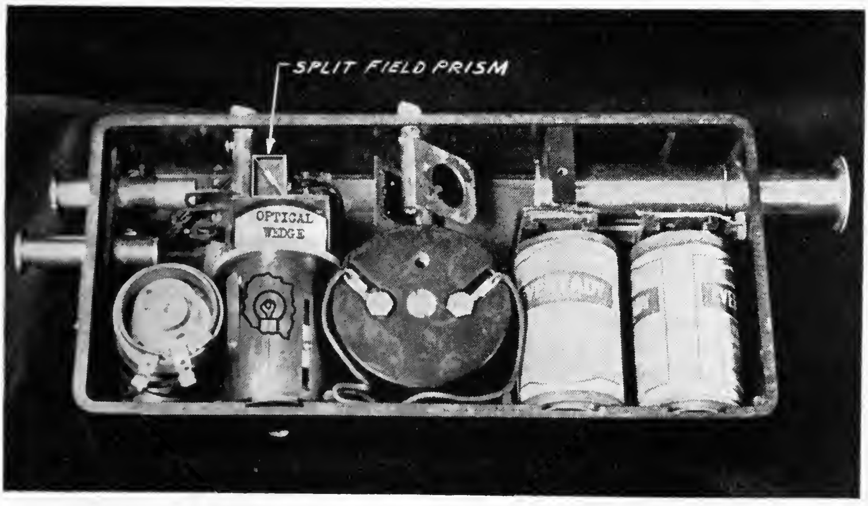

Fig. 2. Comparison-type brightness meter.

The same autotransformer boxes proved to be of help in the problem of measuring the high light intensities involved in high-speed photography. The ordinary exposure meter is not usually considered of much use in measuring high light intensities. However, with several supplementary devices, we have used such meters with much success. The meters are provided with perforated screens giving a multiplying factor of 5 on their indication. In addition, light measurement is carried out with line voltage applied to the lamps. This voltage is noted on the voltmeter mounted in the autotransformer boxes, and from the set of curves shown in Fig. 1 an additional multiplying factor is determined, to be applied to the light reading when the lamps are operated on higher voltage. This factor usually runs between 5 and 9 times and is dependent only upon lamp voltage at which light measurement is made and voltage at which the lamps are operated when the film is exposed. These ratios have been carefully determined by measurement with three different light-measuring devices and have been found to be very reliable. It can be seen that the employment of the exposure-meter filter and light-ratio method allows us to increase the light intensity which can be measured with conventional equipment by approximately 25 to 50 times. Light levels this high are suitable for high-speed photography up to the maximum speeds possible with rotating-prism cameras and allow plenty of margin so that smaller lens openings may be used.

Light measurement is frequently made on a substitute surface of paper having about 25 to 50% of the reflectivity of pure white. This is usually wise when the subject area is largely dark but does have small light-colored or highly reflective sections which must not be overexposed. Figure 2 is an interior view of a brightness meter which is very helpful when it becomes necessary to measure the light level on small areas or parts located in deep recesses where the conventional meter cannot be used. The subject is observed through the upper lefthand eyepiece and is viewed through a split-field prism having a hexagonal pattern in the center which receives its illumination from the light source below through an optical wedge or circular gradient filter. The subject is brought into focus with the lens tube at the right and with the current to the lamp set to the value indicated on the meter, the back of which may be seen at lower center, the optical wedge is rotated until brightness of the hexagonal pattern and brightness of the desired section of the field are matched. If the subject is too bright for a match, a multiplication of the range by a factor of 10,100 or 1000 is possible by inserting either one or both filters located at the upper center. The brightness level is read through the lower lefthand eyepiece from a scale surrounding the optical wedge. The range of this instrument is from 0.000005 to 110 c/sq in. The highest light level which can be measured with this instrument is therefore about 10 times the upper limit of the conventional meter and with the application of the light-ratio method previously mentioned, the measurement of any light level we may care to use or be able to attain appears to be possible. This meter was developed by Matthew Luckiesh and A. H. Taylor of the General Electric Lighting Research Laboratory. A brightness meter having somewhat similar features and manufactured by Salford Electrical Instruments, Ltd. of Great Britain was described in the New Products section, page 184, of the August 1951 *Journal*.

There is a strong tendency in high-speed photography to neglect the planning and preparation of the subject for the picture to be taken. We are often working with engineers from various divisions on mechanisms with which we are not familiar. It is wise in such a

Fig. 3. Commonly used lenses and extensions.

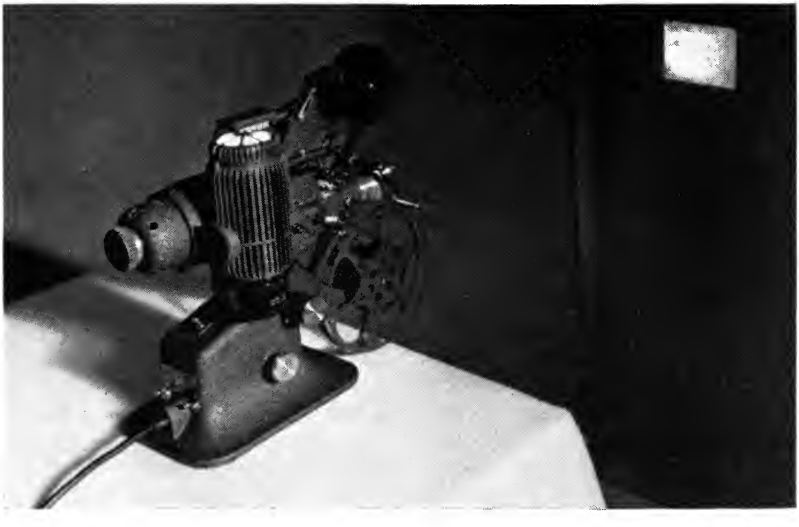

Fig. 4. Direct plotting of motions with time and motion study projector.

case to determine just what parts of the mechanism must be seen and what information will be needed from the film. If movements are to be measured, a scale is necessary and if only small movements are expected, every effort should be made to reduce the field covered by the camera. One basic rule we try to follow is to restrict the camera field to only that which is absolutely required to show the action. There are those who will try hard to have the entire engine included when only the action of a valve spring is under study. It should be obvious to even the most enthusiastic camera designer that movements of a few thousandths of an inch cannot be shown in a field five inches wide and yet just that sort of thing is expected by many people who want high-speed motion pictures taken.

To take care of the various field sizes which may be required when camera-to-subject distances are not a matter of choice, we use a variety of lenses and lens extensions. These are shown in Fig. 3. At the bottom of the picture are lens-plate shims of various thicknesses used to permit lens mounting at distances from film between normal and that possible with the shortest bayonet extension seen above to the right. In the lower righthand corner of the picture is a bayonet adapter used to mount the lenses shown on another camera not so equipped originally. Lenses shown are 254-mm, 105-mm, 2-in. and 35-mm. Although many other lenses are available for these cameras, we have found that those shown take care of a very high percentage of our work adequately. Above the lenses are extensions of various lengths, some variable, some fixed. Any extension up to about 12 in. can be obtained by using these tubes singly or in combination. The use of a long extension in connection with the 254-mm lens will provide as much as 5 times magnification of the image on 16mm film. Such magnifications have been useful in photographing contact action, small vibratory movements and spot and projection welding. When close-up photography is being performed, it is of course necessary to correct the lens aperture used for the amount of lens extension employed as this might otherwise reduce the exposure considerably.

When a subject is being prepared for high-speed photography it is well to plan beyond the basic uses to which the film is to be put and anticipate the need for additional information from the pictures. It is always wise to provide an accurate time base for the film either in the field covered, if frequent reference must be made to it, or at least along the edge of the film as furnished by the timing units provided for these cameras. Dimensional information should be given somewhere in the field of view by scales located close to the plane of motion or by marks placed a known distance apart on the subject. If the motion of a part of the subject relative to a stationary object or to another part is to be determined, a scale should be appropriately mounted to show this motion directly. Often the only requirement of a film is to show the character of a motion in comparing various conditions; however, the provision of scales and timing for more specific evaluation is usually good foresight.

Figure 4 shows a time and motion study projector being used to plot the action of a high-speed camera subject. Such projectors designed for time and motion study of production operations by methods-engineering and standards groups have features which suit the job of analyzing our films very well. This machine projects a very bright clear single frame and has a hand crank which moves the film four frames per turn. In addition a frame counter is provided which can be reset to zero on any frame desired. This makes plotting on any desired picture interval easy, allows a precise accounting of motion relative to frame count and simplifies the de-

Fig. 5. Camera and mirror mounted to photograph suspension action on car.

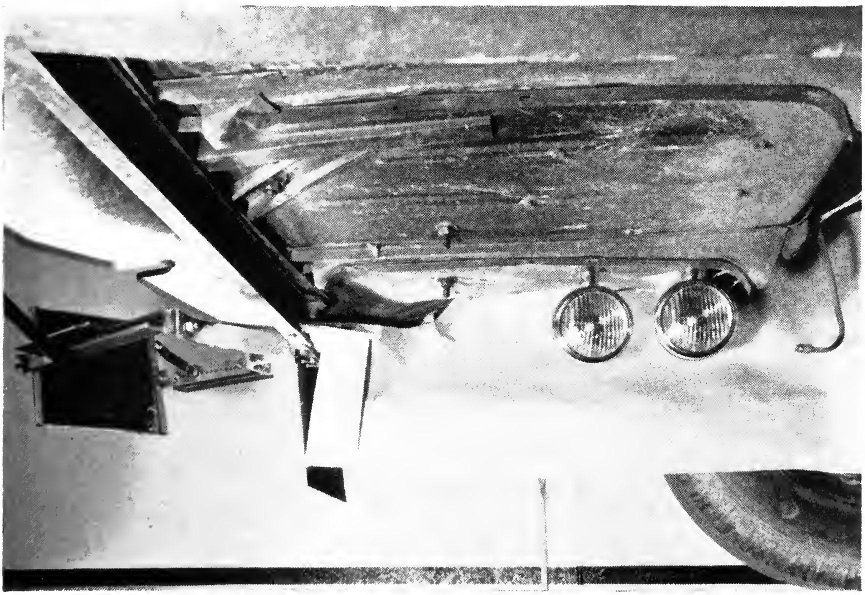

Fig. 6. Underside of car showing mirror and lights used to photograph suspension action.

termination of picture-taking rate. This projector also features governor-controlled projection rate which is adjustable from 800 to 1200 pictures per minute. This feature makes it possible to quickly make time measurements directly from the film. This is done by adjusting the projector speed so that the elapsed time between timing marks, or an interval on the time scale as checked by a stopwatch, is a convenient multiple of the actual time represented. It is then a simple matter to use the stopwatch to check time in the motion of the subject and divide this by the predetermined multiple to get true time. Reasonable accuracy may be obtained in this manner provided reference is made to the time base along the same section of film as is being studied.

The arrangement in Fig. 4 is used to plot subject motions directly on graph paper. The projection distance is adjusted to make the dimensions scale 1:1 or some convenient ratio. In this case all motions of interest were horizontal and timing marks were provided on the film at 0.001-sec intervals. Horizontal motions were plotted against time on the vertical scale and the projector elevating mechanism was used to position the picture for plotting while a stationary reference line on the subject was used in following one of the vertical chart lines.

The photography of moving vehicles and various components on them such as suspension members, accounts for about 20% of our film footage. Figure 5 shows a camera mounted in the trunk of a car using a mirror to obtain a view of the rear spring and shock absorber. Mirrors can be very useful in getting views from otherwise difficult angles. Mirror shake usually gives no trouble since at the frame speeds employed it results in only a slow drift in the projected picture. Figure 6 is a view underneath the same car with the gasoline tank removed to allow a better view of the subject. The lights used in this case are fog-lamp units having an elongated beam of light quite suitable for illuminating the spring. Batteries were used to power the lights and an overvoltage of about 75% was applied to increase the illumination intensity. Camera power was likewise derived from batteries, although a motor generator a-c source is frequently used for this purpose.

Another method of photographing moving vehicles which we use involves setting up the camera alongside the roadway and either following the vehicle by panning the camera or allowing the vehicle to pass through the field of the camera. Still another method employed with success involves a car to carry the camera and run alongside the subject vehicle while the picture is taken. The camera is sighted on the subject through the use of a simple sighting arrangement and the camera operation is initiated when the subject is properly centered in the sight. This method of taking moving-vehicle films has been especially successful and since the time involved in running the film through the camera is only a few seconds no great difficulty exists in keeping the subject in view once it is lined up.

At one time it was desired to photograph the action of a tire tread as a car was accelerated from a standstill. The best view and perhaps the only view possible could be taken from just one position, underneath a plate-glass surface on which the tire rested. Figure 7 shows the tire on a heavy piece of plate glass. The camera setup below the plate glass is shown in Fig. 8. Although the coefficient of friction between plate glass and rubber was naturally somewhat different from that between normal road surfaces and rubber, the general behavior of the tire tread was quite informative.

The application of high-speed photography to the study of combustion in a gasoline engine is by no means new; however, steady progress has been made

Fig. 7. Wheel on plate glass for tire tread photography.

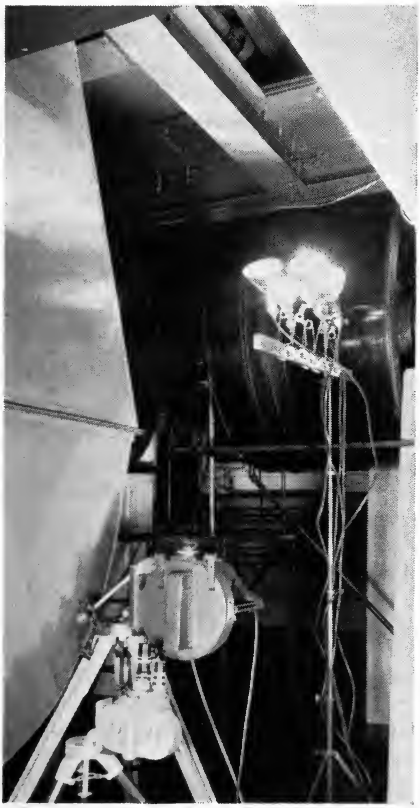

Fig. 8. Camera and lights arranged to photograph tire tread action.

in the methods used in taking pictures of this sort. Rassweiler and Withrow of General Motors Research Laboratories started on the problem of combustion photography well over fifteen years ago and a number of papers on their methods have been presented before various engineering society meetings.[1] This work has been continued right up to the present time under Mr. Withrow's direction. Figure 9 shows one of the quartz-window engines being used for combustion study. One of the principal aims of this work has been to obtain films of the progress of the flame front during both knocking and nonknocking combustion and to observe carbon particle formation. For this work it is not considered desirable to use fuel additives for the purpose of increasing flame brightness, therefore camera frame rates have been held to around 1500/sec or 2000/sec in the interest of good exposure. Sensitive films such as linagraph pan are usually employed and fast camera lenses are required. Lenses of either *f*/1.9 or *f*/1.5 aperture rating are usually used. In Fig. 9 three light sources can be seen. These are ultraviolet lamps which have replaced ordinary incandescent illumination for delineating the cylinder outline. The use of visible light for illumination tended to wash out the exposure of the cylinder area due to the light reflected from the combustion chamber. Now used is an outline mask to which have been applied fluorescent coatings which glow brightly under ultraviolet light. The value of these films depends upon precise determination of crankshaft angle for each frame. This information is provided by the crankshaft position scale seen at the lower center part of Fig. 9. Just above the scale is an optical arrangement which places an aerial image of the scale in the plane of the quartz window. Figure 10 is a view of the quartz window and crankshaft scale as seen from the high-speed camera position. The cylin-

der outline mask has been coated with a variety of fluorescent materials such as vaseline, solium and coatings known as "da-glow," "glo-craft" and others. The various materials on the mask were being compared for intensity of fluorescence. It is interesting to note that in the first use of ultraviolet light on the mask alternating-current sources were employed and the cyclic variations in mask illumination were quite disturbing. Direct-current units are now used to supply the ultraviolet light.

The action of the subject for a high-speed motion picture may have associated with it certain electrical or other phenomena which would add much to the picture if simultaneously recorded. In some cases this information can be conveyed through the use of the timing lamp, but often is too complex for recording by this means. Transducers such as microphones, vibration pickups or strain gages, can be of use in recording this other information on the film. A method we have used to perform simultaneous photography of a subject and associated characteristics is shown in Fig. 11. A cathode-ray oscillograph is used to convert the electrical information to a trace suitable for photography. A small first-surface mirror is positioned so that it combines the oscillograph trace with a view of the subject in the camera field of view. Camera-to-subject distance and camera-to-oscillograph screen distance via the reflected path must be made equal so that a sharp focus may be had on both. Modern cathode-ray oscillographs can provide a trace sufficiently bright for good exposure when using a high-speed camera of the commercial variety at maximum frame speed. The subject of the setup in Fig. 11 was the contact action of an auto radio vibrator and the input current waveshape was displayed on the oscillograph. There are, of course, other methods of showing electrical variations along with mechanical action; however, it is felt that the versatility, sensitivity and ease of calibration as well as trace-positioning simplicity and flat response of modern cathode-ray oscillographs should be fully considered in this application.

The study of valve spring and valve motions in engine work is simplified greatly through the use of high-speed photography. Figure 12 shows equipment used to measure exhaust valve motion on an overhead valve engine. This procedure is similar to one used by Thompson Products Co., and a more specific description of the results achieved is contained in a paper by Thoren, Engemann and Stoddart, presented before the Society of Automotive Engineers.[2]

In the illustration shown, an 8mm high-speed camera was used and mounted horizontally so as to take advantage of the 16mm frame width available when using a special aperture plate. Camera speeds employed were as high as 15,000 frames/sec at higher engine speeds. A vernier indicating device was rigidly mounted to the engine head and the sliding scale which was very light in weight was welded to the valve-spring retainer cap. The resulting pictures of the vernier could be read easily to 0.001 in. of valve movement. The fixed vernier scale was provided with two holes through which the flash tube of a Strobolux flash unit could be seen from the camera position. This flash was triggered from a contact arranged to close at top center for the cam of the valve being studied. Interpolation of the film for camshaft angles between flashes was accomplished by using elapsed frames as a basis. Figure 13 shows valve-motion curves obtained by this method for an engine speed of 4600 rpm. This represents an extreme condition rarely encountered in actual service. The solid line represents the ideal valve-lift curve. The curve traced in long dashes shows the motion with a solid valve lifter and it should be noted that valve open-

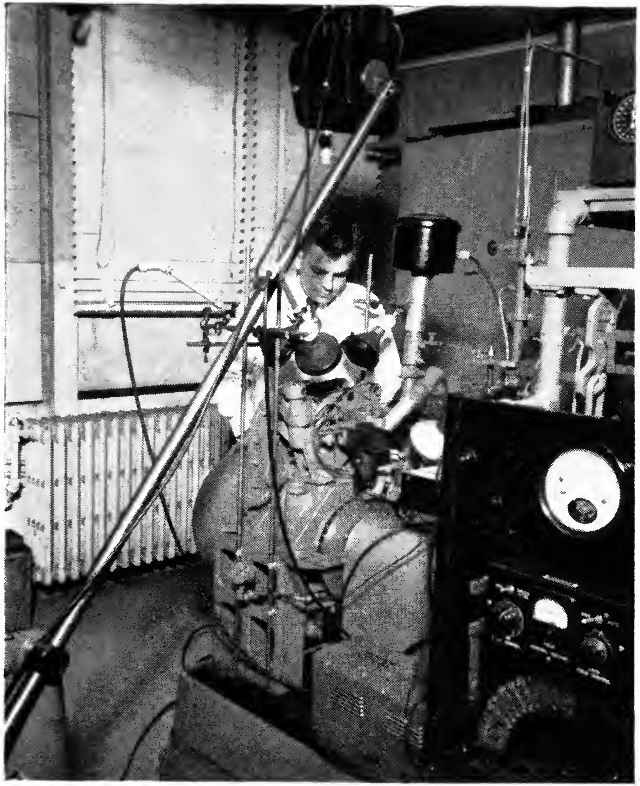

Fig. 9. Equipment arrangement to photograph combustion in quartz window engine.

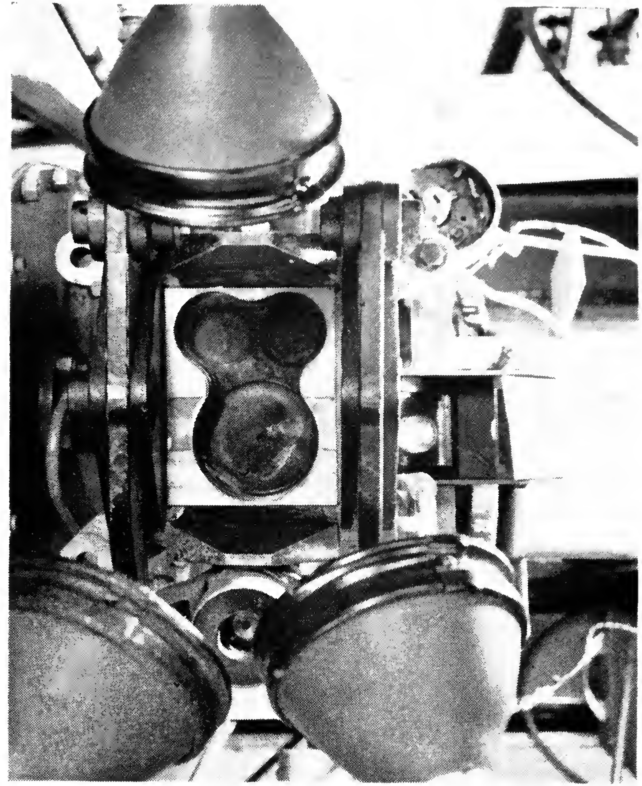

Fig. 10. View of quartz window engine as seen from camera position.

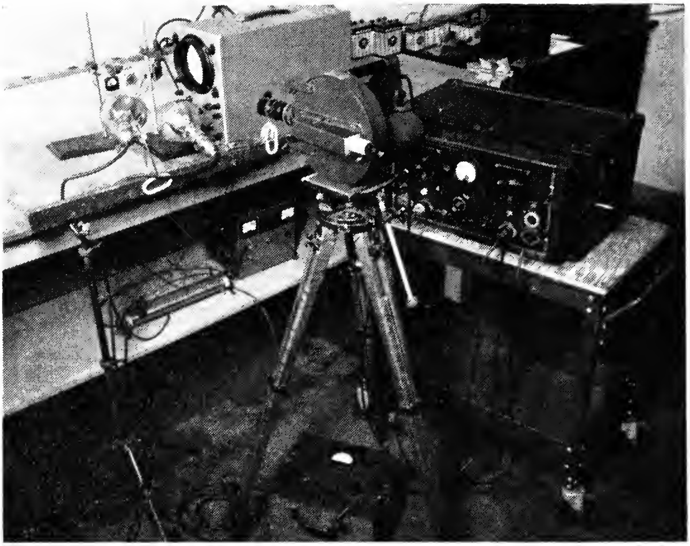

Fig. 11. Setup for simultaneous photography of contact action and oscillograph trace of waveform.

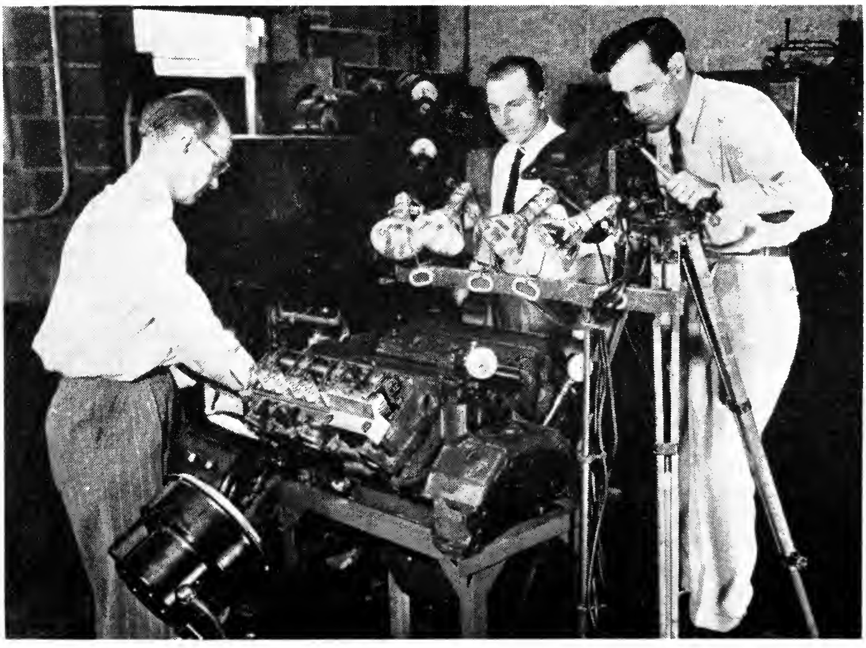

Fig. 12. 8mm camera and equipment used to photograph engine valve motion.

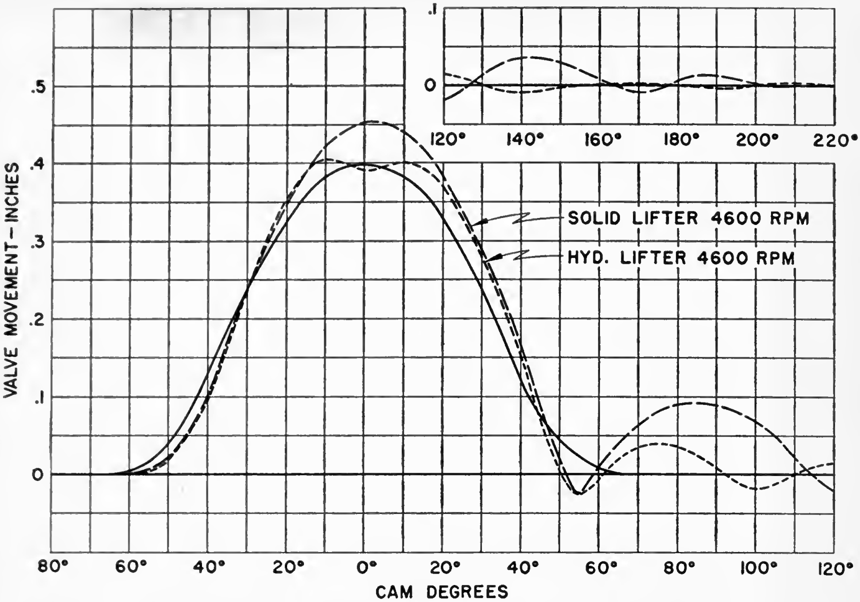

Fig. 13. Valve motion curves for 4600 engine rpm as plotted from film.

ing greatly overshoots the ideal curve at top center and the valve does not follow the calculated curve except as it begins to open. It is interesting to note that the valve goes through about four bounce cycles upon closing before it settles down. The curve traced in short dashes is the one obtained with a hydraulic valve lifter and it is to be noted that even in this extreme condition it more closely follows the ideal curve with less overshoot and evidently with less impact and bounce upon closing. The departure of measured valve motion from the ideal curve is caused by forces and elastic deflections within the valve train at higher engine speeds. This method of checking valve motion is used to verify improvements in valve motion brought about by a method of designing cam contours to allow for the dynamic forces in the valve train at high speeds. Engineers familiar with valve-train design say that no other method is available for checking valve motions as accurately as through the use of high-speed motion pictures.

The methods described here and many others, have been used by General Motors Proving Ground over the past thirteen years with excellent results. They have been instrumental in many product improvements and have pointed the way in a number of instances to more dependable designs and more efficient production operations. High-speed photography seems destined to play an ever-increasing part in our design and experimental activities in the future.

References

1. G. M. Rassweiler and L. Withrow, "High speed motion pictures of engine flames," *Ind. Eng. Chem.*, *28:* 672–677, June 1936.
2. T. R. Thoren, H. H. Engemann and D. A. Stoddart, "Cam design as related to valve train dynamics," *S.A.E. Transactions*, *6:* 1–14, Jan. 1952.

A Direct-Projection System For Theater Television

By FRANK N. GILLETTE

The Simplex Model PB-600 contains all facilities required for operation from any of the standard sources of television signal. It projects on the theater screen a full-size television picture of the highest quality compatible with the present state of the art. The system combines simplicity in installation, convenience in maintenance and reliability in operation. This paper describes the circuitry and mechanical features of the system components, and presents the design considerations which governed the development.

The Simplex system consists of three compact units: a control-panel cabinet, a high-voltage supply and an optical barrel. The installation location of these units is indicated in Fig. 1.

The control-panel cabinet, Fig. 2, contains all of the operating controls and the large majority of alignment and service controls. This unit would normally be installed in the projection booth, but in the case of a crowded booth, many alternate locations are possible.

The high-voltage supply, Fig. 3, can be installed in almost any convenient location. It has no controls, meters or switches mounted on it and should require no attention for months at a time.

The optical barrel, Fig. 4, does have some critical installation requirements. Since the projection optics have a fixed focal length and have, moreover, an extremely wide aperture, the optimum location for the barrel is fixed, within rather narrow limits, by the size and location of the projection screen.

The projection screen itself may be regarded as a component of the theater television system or as a part of the existing theater equipment. The screen should be selected for optimum reflection of incident light into the audience area. This might occasionally dictate the use of a beaded screen, but only if the theater is quite narrow. With a wider theater, beaded screens would probably be rejected because of their very poor performance at large reflection angles.

In many installations it will be advisable to use the screen already present. This screen will presumably have been selected because its reflection properties are suitable for the shape and size of the theater. Of course, the existing screen may be too large, requiring masking to a

Presented on October 15, 1951, at the Society's Convention at Hollywood, Calif., by Frank N. Gillette, General Precision Laboratory, Inc., 63 Bedford Rd., Pleasantville, N.Y.

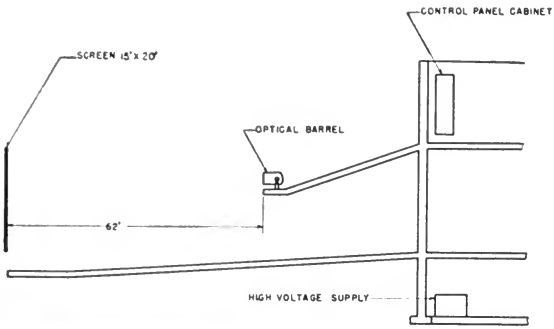

Fig. 1. Equipment locaton, Simplex Model PB-600.

Fig. 2. Control-panel cabinet, Simplex Model PB-600.

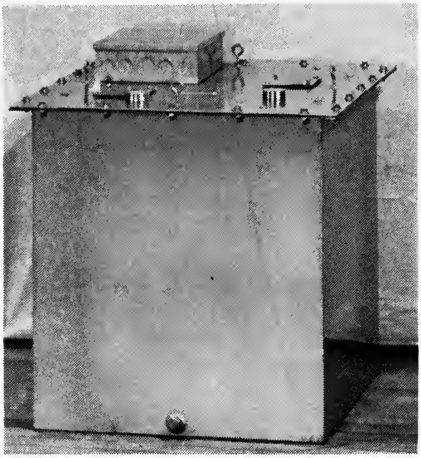

Fig. 3. High-voltage power supply, Simplex Model PB-600.

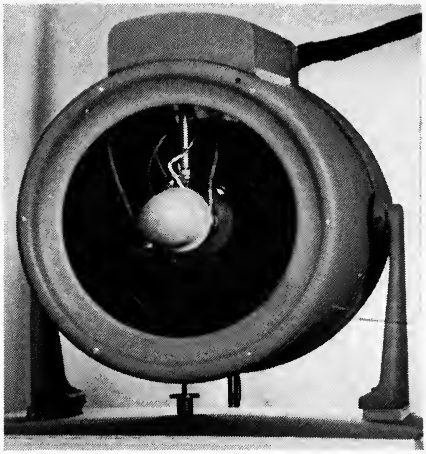

Fig. 4. Optical barrel, Simplex Model PB-600.

smaller size during periods of television presentation.

The optical system is designed to provide a picture 15 ft high and 20 ft wide at a throw distance of 62 ft. The system does permit some variation of picture size and throw distance, but there are also some unyielding restrictions on such variation. The many inquiries we receive on the subject of picture size and throw distance indicate the advisability of calling specific attention to the nature and source of these limitations.

Figure 5 shows the optical elements of the system. The picture is formed on the face of the cathode-ray tube shown at T. Light from the tube face is collected by the mirror at M and directed toward the projection screen at S. The corrector plate is inserted at P for the purpose of correcting aberrations, principally the spherical aberration of the mirror.

The design of the entire optical system is fundamentally controlled by the cathode-ray tube, in this case a Type 7NP4. For good focus over the entire picture area, it is necessary that the curve of the mirror be essentially concentric with the curve of the tube face. It is further necessary that the tube face be located approximately at the focal point of the mirror. Since the focal length of a spherical mirror is equal to one-half its radius of curvature, the foregoing conditions result in a mirror having a radius of curvature twice that of the cathode-ray tube and a system having a focal length equal to the radius of curvature of the tube face.

With the focal length fixed in this way, there is then a single value of magnification for any chosen throw distance. Thus, picture size at a fixed throw distance can be changed only by changing the size of the picture on the cathode-ray tube. If the size is increased too much, the corners will be clipped by the edge of the tube. If the size is decreased appreciably, resolution will suffer. In practice, the dimensions of the picture can be varied some 10% either way from the nominal size.

The magnification is, of course, a linear function of the throw distance, but throw distance is not readily controlled. Throw distance is strongly influenced by the design of the theater and can be manipulated only by reconstruction of a more or less extensive nature. If the preferred installation location provides a

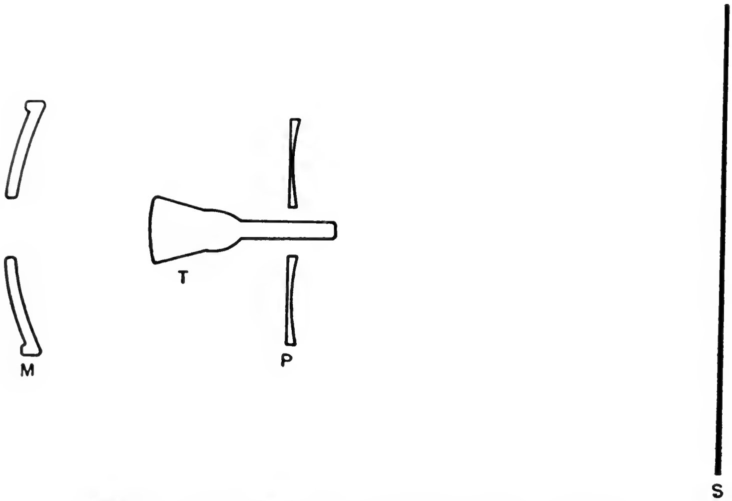

Fig. 5. Optical elements, Simplex Model PB-600.

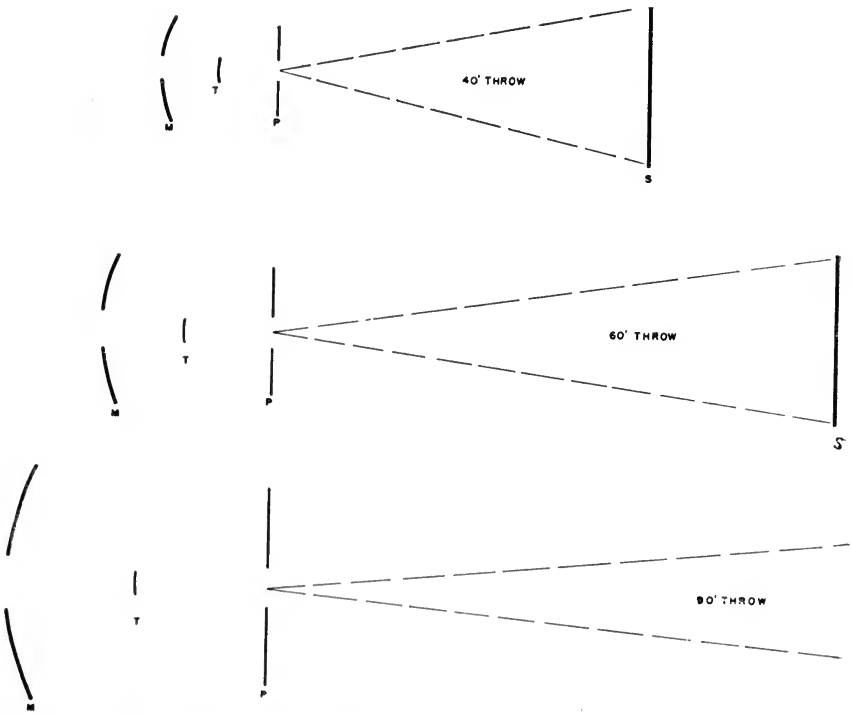

Fig. 6. Effect of focal-length variation, Simplex Model PB-600.

throw that is too short, use of a smaller screen is possible and provides the attendant advantage of increased screen brightness. If the preferred location gives a throw that is too long, the only answer is theater modification. Increasing the screen size is not recommended because the brightness soon becomes unacceptably low.

Theater people are quite familiar with these relationships between picture size, throw distance and focal length. Unfortunately, they are also accustomed to purchasing projection lenses in many different focal lengths scattered over such a wide range as to satisfy almost any requirement of picture size and throw distance. Quite naturally, they expect to find a similar flexibility offered in theater television equipment.

The cost of designing and stocking expensive optical systems of different focal lengths is one obvious reason for not offering such flexibility. Other, and perhaps even more forceful, reasons are indicated in Fig. 6 which shows the effect of focal-length variation. The middle drawing, illustrating the 60-ft throw, shows the components of our present optical system; the upper drawing shows a system using a shorter focal length; the lower drawing shows a system using a longer focal length. As drawn, the three systems provide approximately the same screen brightness.

It will be noted that the diameters of the optical elements of the system of longer focal length are considerably larger than the elements of the "Simplex" system. Not only are such elements much more expensive than those used in the present system, they are also larger than can be manufactured in quantity by existing equipment. The system of shorter focal length involves smaller components which could indeed be manufactured at reasonable cost. However, the angular width of the picture becomes significantly greater. As this angular width becomes larger, the optical design problem becomes tremendously more complex. Adequate correction of optical aberrations in the corners of the picture becomes virtually impossible.

Although an optical system of this type is generally called a Schmidt system, it differs tremendously from the system originally developed by Schmidt for use as an astronomical telescope. Fundamentally, a Schmidt system consists of a spherical mirror, a diaphragm located at the center of curvature of the mirror, and a corrector plate also located at the center of curvature. The diaphragm serves to eliminate third-order aberrations and the corrector plate provides compensation for spherical aberration. The optical quality of this system can indeed be very good, provided the design is restricted to an angular field of something like 1° and an aperture less than $f/3$. For the "Simplex" system, an angular field of 23° and a geometrical aperture of $f/0.7$ is required. Clearly, these requirements are well beyond the limitations of the basic Schmidt design.

The classical Schmidt formulas have been applied to the present conditions with a reasonable degree of success. However, much better results have been obtained by approaching the design problem from a somewhat different point of view. Louis Raitiere of the General Precision Laboratory has succeeded in developing a design approach which results in a system that differs slightly, but very significantly, from the classical Schmidt system. The performance obtained with Raitiere's optical system has been quite gratifying. A limiting resolution in the extreme corner of the field of 2000 television lines per picture height is observed. This figure, of course, applies to the optical system alone and not to the overall system.

The detail-contrast ratio that can be obtained in any system which works with a cathode-ray tube as the basic picture source is never as much as one would desire. The contrast ratio is still further de-

graded by the presence of any dirt on the optical elements of the system. To reduce the rate at which dirt collects on the optical elements, and consequently to minimize the necessity for frequent cleaning, the optical barrel, shown in Fig. 4, has been designed. The barrel is completely enclosed and there is no circulation of outside air through the system. The cooling air which must be directed against the face of the cathode-ray tube, to avoid damage to the tube, is recirculated through the barrel and serves only to conduct heat from the cathode-ray tube to the outer walls of the barrel. The outside of the barrel provides such a large radiating surface that the resulting temperature rise is insignificant.

The use of a closed system also permits quite simple solutions to any problems arising from excessive humidity. Thus far no difficulty with arc-over within the barrel has been encountered, but should such difficulty develop, no trouble in controlling the humidity within the unit is anticipated.

The barrel is supported mechanically at three points. The two pivot points are located at approximately the center of gravity and carry the bulk of the weight of the unit. The third support point is at the bottom of the front of the barrel. Its function is to tilt the barrel and to hold the line of sight, once it is established. The maximum tilt, permissible from optical considerations, is approximately 7°. If it is possible to tilt the screen, a greater tilt of the barrel can be accommodated by the mechanical adjustment provided.

The barrel opens at the top for cleaning and service. The video amplifier and the alignment controls are located here, which makes readjustment or tube replacement very simple. Of course, there are no more tubes in the barrel than is absolutely necessary. Only the final video amplifier is located here.

The cathode-ray tube is mounted in the deflection yoke which is in turn held by a support arm that hangs from the top of the barrel. The support arm fastens to a mounting plate from which it can easily be removed and to which it returns without disturbance of previously made alignment adjustments. All alignment adjustments required by tolerances of the cathode-ray tube itself are made on the support-arm assembly. Thus, any operator who may wish to do so can equip himself with a spare tube support arm in which he can mount and align a spare cathode-ray tube to have it in instant readiness for replacement in case of tube failure. To facilitate this operation, all electrical connections to the cathode-ray tube and the deflection yoke are carried up the tube support arm to connectors that can be quickly disconnected in time of need. With these provisions, a show need not be lost for more than three minutes by failure of the cathode-ray tube.

The 80-kv power supply is shown in Fig. 3. This unit provides the anode voltage for the cathode-ray tube and also the focus voltage.

The circuit employs a 60-cycle voltage doubler using two Type VR3B rectifiers. The output voltage is regulated against variation in both line voltage and load current by an electronic regulator which controls a saturable reactor in series with the primary of the high-voltage transformer. The regulation characteristic is essentially flat from zero current to 2.5 ma. Beyond 2.5 ma, the voltage drops rapidly with increasing current in the manner required for protection of equipment against permanent damage in case of momentary failure.

The focus voltage is bled from the 80-kv level to take advantage of the stability of that level and to provide a focus voltage that will remain proportional to the anode voltage, should any variation in that level occur. Remote control of the focus voltage is provided by a high-voltage triode used as a shunt across the low end of the focus bleeder.

The unit is oil filled for maximum reliability. It also contains a number of electrostatic shields and protective spark

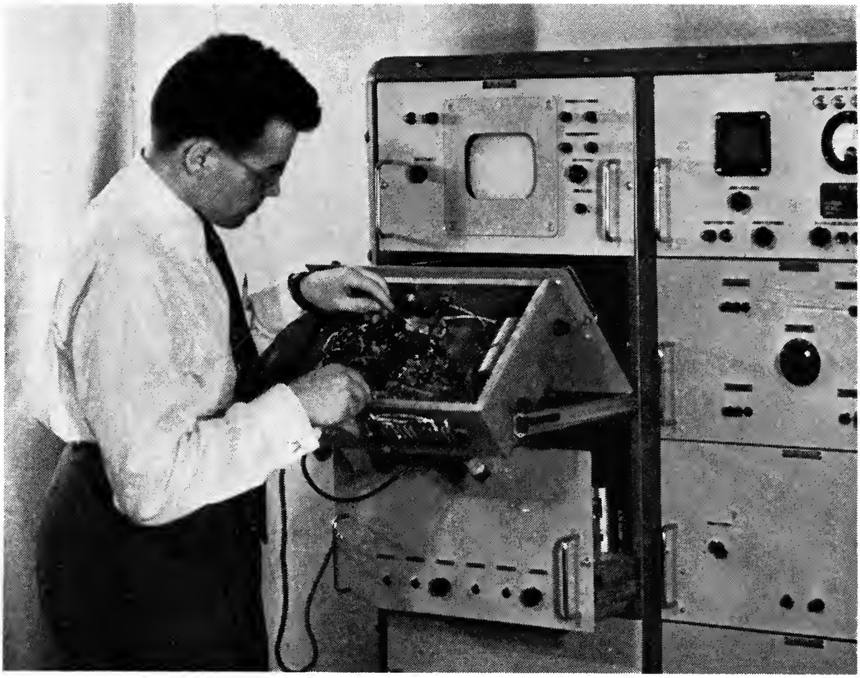

Fig. 7. Control-panel cabinet servicing, Simplex Model PB-600.

gaps on the low-voltage wiring to ensure that any breakdown which might occur inside the unit will have no harmful effect on external circuits.

The booth equipment consists of the Control-Panel Cabinet, shown in Fig. 2. It is a double-relay rack, each rack being of the standard width to accommodate 19-in. panels.

The rack itself possesses a number of special features that deserve mention. The component chassis are strictly conventional, each one consisting of a horizontal chassis with a vertical front panel of standard 19-in. width. However, the method of mounting is such as to provide much greater serviceability than is usually found in equipment constructed in this fashion. Each individual chassis is held in place with two quarter-turn locks. When these are released, the chassis may be drawn forward on rollers until it is fully clear of the rack. This provides quick access to all of the tubes in the rack without the removal of cover plates or other ornamentation (see Fig. 7).

Should the wiring side of the chassis require attention, it is necessary only to lift the front of the chassis and swing it upward through 90° where it will rest in a stable position with the wiring facing outward. In either of these positions the chassis is still connected and still operating.

These provisions make it possible to perform all service functions without access to the rear of the rack. This same thought has been carried further. When all the chassis are removed from the rack, there remains but an empty shell. As a first step in installation, this shell can be bolted, once and for all, in its final position even though this places the back of

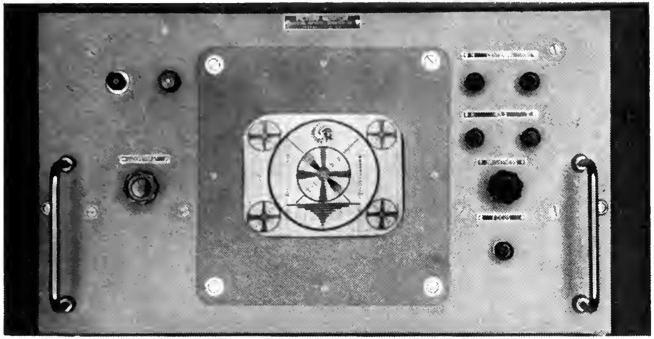

Fig. 8. Picture monitor panel, control cabinet, Simplex Model PB-600.

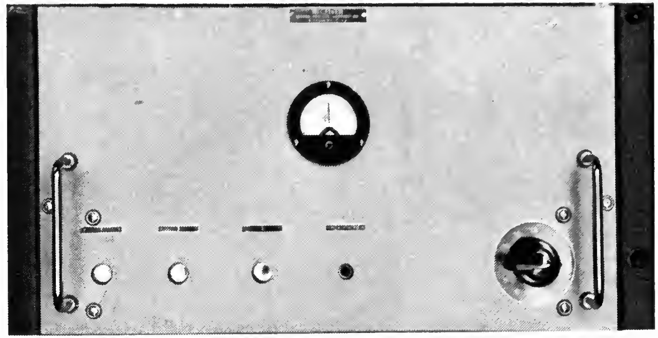

Fig. 9. Receiver panel, control cabinet, Simplex Model PB-600.

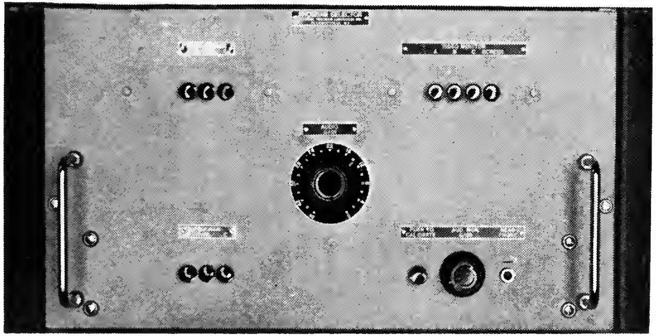

Fig. 10. Program selector panel, control cabinet, Simplex Model PB-600.

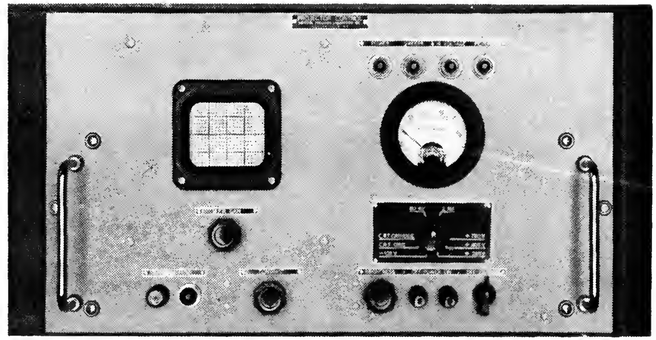

Fig. 11. Projector control panel, control cabinet, Simplex Model PB-600.

the cabinet solidly against a wall. The conduits and cables can then be affixed and the chassis installed without further movement of the cabinet.

The equipment in the racks is so distributed as to place the monitors and meters at eye level and the operational controls at convenient finger-tip level.

The unit in the upper left corner is the Picture Monitor, containing its own power supply. The controls on this unit serve only to adjust the picture on the $8\frac{1}{2}$-in. monitor tube (see Fig. 8).

Below the monitor is a receiver of rather superior characteristics which provides off-the-air reception during periods of test and alignment (see Fig. 9).

The two units below the receiver are the vertical and horizontal deflection chassis (see Fig. 2). These units contain all of the deflection controls, circuits and components except the deflection yoke, which is necessarily located with the projection tube in the optical barrel. The deflection circuits and components are especially designed to permit a long cable connection to the deflection yoke. With the cable usually provided, this run can be 150 ft. With special low-capacity cable, even longer runs are possible. This point is mentioned particularly because this cable run is the only one in the system that bears any restriction as to length.

Below the deflection chassis are two blank panels behind which is located a line-voltage regulator that stabilizes the input voltage to various circuits that are not sufficiently critical to demand electronic regulation, and to the filament transformers of more critical circuits.

The bottom panel of the right-hand rack is also blank. In this space the saturable reactor, which regulates the 80-kv supply, is mounted.

The two chassis directly above contain power supplies which provide the various plate and bias voltages required by all of the circuits except the monitors.

Above the power supplies the Hi-Voltage Control Unit is located. This unit contains all of the low-voltage elements associated with the 80-kv supply except the saturable reactor mentioned earlier. The panel controls consist of pushbuttons for controlling power to the supply and a knob for setting focus-voltage level.

The remaining two panels in this rack are shown in more detail in Figs. 10 and 11. Figure 10 shows the program-selector panel located immediately above the high-voltage control unit. All of the signal switching and audio-control functions of the equipment are performed at this panel.

The system provides for three incoming program channels, each consisting of an audio and a video line. Normally, one of these channels will be connected to the receiver included in the equipment. The second will take the incoming program line. The third might be used for a parallel safety channel for the main program line, for an auxiliary microwave receiver or possibly for a local signal generated by pick-up equipment within the theater.

The switching facilities permit independent monitoring of any incoming audio or video line. The three panel pushbuttons at the upper left connect any of the three audio lines to the monitor headphone jack in the lower right corner of the panel. The gain control for the monitor channel is adjacent to the phone jack. The larger knob sets gain in the program line to the theater. This control is used only to set the audio level from the television equipment to the level required by the input of the theater sound system. It is not considered an operational control.

The pushbuttons at the upper right switch the input signal to the Picture Monitor and also to the Waveform Monitor, yet to be described. The first three buttons select any of the three incoming video lines. The fourth button is labeled "Screen." Its function will be described in connection with the Projector Control Panel. An additional

nonlocking pushbutton, located nearby and labeled "Push to Calibrate," serves to connect a calibrating signal to the Waveform Monitor for use in setting signal levels.

Program switching is done by the pushbuttons at the lower left of the panel. They feed any of the three input channels to the theater system, controlling both picture and sound. Interlocked switching has been used here as another means of eliminating operator error.

Figure 11 shows the Projector Control Panel which is located at the top of the right-hand rack. On the Projector Control Panel are concentrated all but one of the operational switches and controls normally used in turning on and adjusting the theater screen picture. This panel also contains the waveform monitor and a multipurpose meter, both very useful as monitors during projection and as test instruments during preliminary setup.

The equipment will normally be turned on by the four-step procedure outlined below. However, the equipment contains enough interlocks and protective circuits to ensure that no damage will result no matter how carelessly the operator handles his turn-on procedure. In any case the progress of the operation is indicated by the condition of four amber lights at the upper right of the Control Panel. Not until all four are illuminated will a picture appear on the projection screen.

As the first step of the procedure, the main power relay is closed by means of the motor-starting-type pushbutton located below the meter. This causes immediate glowing of the first of the amber lights.

While the circuits warm up and reach normal operating conditions, the second amber light begins to glow, indicating the presence of deflection fields at the cathode-ray tube.

As the second step, power is applied to the Hi-Voltage Supply by means of the pushbuttons located on its control panel. In a short time the anode potential rises to its proper level, causing the third amber light to glow.

At this point, the entire system is turned on and the three lights inform the operator that all interlocks are closed, all supply voltages are present and most of the circuits are functioning in essentially normal fashion. However, there is still no picture on the projection screen because the projection tube is biased well beyond cutoff.

The third step might be considered optional, but is actually essential to good showmanship. It consists of using meter and monitors to preset various controls to ensure that the picture first seen by the audience is a good picture.

The test meter is used first to check the levels of the various supply voltages, including the 80-kv anode supply. It is then used to set the operating bias of the projection tube at the proper level by means of the "Brightness" control. Finally, it is turned to the "2MA" position to serve as a monitor during the projection period.

The monitors, both picture and sound, are used first to check on the quality and the levels of the incoming signals. Then the picture and waveform monitors are switched to their "Screen" position. In this condition, both receive a video signal brought back from the final video stage in the optical barrel, which permits preliminary adjustment, by means of the "Contrast" control, of the actual driving signal applied to the cathode of the cathode-ray tube.

Furthermore, when the Picture Monitor is switched to the "Screen" position, its horizontal and vertical sweeps are synchronized directly by pulses obtained from pickup coils wound into the deflection yoke of the projection cathode-ray tube. Since these pulses are actually a measure of the magnetic deflection fields applied to the projection tube, a normal picture on the Picture Monitor is a positive indication that the deflection

signals, applied to the projection tube, have the correct frequencies and essentially the correct amplitudes.

All is now ready for the fourth step. Turning the "Picture" switch to "On," illuminates the fourth amber light, switches the projection tube from cutoff to operating bias and presents the picture in essentially perfect adjustment.

The cathode-ray tube used in this system is rather expensive and, while it is an amazingly tough device when treated properly, it is highly fragile when mistreated. These remarks apply equally well to personnel who operate and maintain the equipment. Consequently, the equipment includes an elaborate system of interlocks and safety devices for protection of tubes and personnel.

The interlock system prevents the application of primary power to the high-voltage supply unless all doors giving access to the anode and focus voltages are closed and all chassis in the rack are in place. The protection system allows beam energy to reach the tube face only when the following conditions are satisfied:

1. Proper voltage levels exist in the +750-, +400-, +285-, −105- and −150-v power supplies.
2. The 80-kv supply is up to operating level but not in excess of 82 kv.
3. Horizontal and vertical deflection fields have at least 75% of their normal amplitudes.
4. A substantial stream of air is blowing against the tube face.

The projection system is designed primarily to prevent damage to the 7NP4 projection tube, but it also serves to protect the remainder of the system against bias failure.

Throughout the system, the protection circuits have been designed to work directly from the critical quantity and not from signals which usually, but not always, denote that quantity. For example, the circuit which protects against sweep failure might work with almost complete safety from various currents or voltages that are readily available in the deflection circuits. Actually, in this case, the critical quantity is the magnetic field in the gap of the deflection yoke. Our protection system includes pickup coils in the yoke which measure the magnetic fields and thus give positive and complete protection against sweep failure.

In designing the system described above, the goal of providing quality of performance, exceeding the requirements of present television standards, has been pursued. The degree of success that has been achieved justifies a prediction that the Simplex equipment will not be found wanting whenever higher performance standards may be adopted.

Discussion

Anon: You mentioned that there was no restriction on the physical separation of the various components in this system with the exception of one point that I don't recall now. How about the distance between the 80-kv power supply and the optical barrel? Won't you get into trouble there with high capacity if you have that distance too great?

F. N. Gillette: In that case you're not in any trouble because of high capacity. Indeed, the cable capacity can be used as an essential and valuable part of the filter system on the 80-kv. If we were actually obliged to use a very short cable we would find it necessary to add capacity in the power supply. We've left space for this purpose in case we hit such an emergency, but we're definitely planning on the capacity of the cable as part of the filter system.

Anon: That isn't the point I had in mind. The larger the capacity in the output circuit of the high voltage power supply the more lethal the thing becomes.

Dr. Gillette: The thing is lethal without any doubt. I don't think it's possible to reduce the capacity to a value which would not be lethal. The only remedy seems

to be to prevent access to the voltage. From the point at which it emerges from the supply itself, until it disappears into the barrel, the high voltage lead is encased in the outer conductor of a coaxial cable and the cable is run in a conduit. We think that's better than trying to keep capacity down.

L. D. Grignon: At the Lake Placid 68th Convention you described a proposed system of 675 scanning lines with a 24/sec frame rate. Is this such a system?

Dr. Gillette: At the moment this is not such a system. We have operated the system in that fashion just to find out how much further we have to go and we are satisfied that we need considerably more filtering in the system than we now have. The observed modulation of any image point is perhaps two television lines. Most of the modulation comes from ripple on the high voltage supply. A small amount is very definitely in the deflection system. These ripple effects are easy to remove, but the equipment we are now constructing is not 675–24 equipment.

Progress Committee Report

PROGRESS in the motion picture studios during 1951 was mainly another step forward in the application of new color systems and in the completion of the installation and operation of magnetic recording equipment.

Feature pictures made with Eastman negative-positive color, Ansco negative-positive color, Eastman color negative with Du Pont color positive, and Eastman color negative with SUPERcine-COLOR color positive are in release.

While the continued economy drive has tended to restrict the production value of some pictures, many producers are experimenting in order to determine just how much the illusion in a picture may be enhanced by the increased scope which is provided by large, spectacularly illuminated sets and complicated routines. As a case in point, the concluding ballet scene in *An American In Paris* was filmed after the picture in its original form was completed![1]

The Telecinema at the Festival of Britain in London deserves special mention in the introduction to this report.[2] This theater was built to demonstrate technical advancements in the projection of motion pictures, sound, and large-screen television. It is open to the public on an admission-fee basis and at last reports was self-supporting.

Large-screen television is shown and people arriving in the auditorium proper see on the screen others in the foyer who are about to enter. Stereoscopic color motion picture short subjects of the Polaroid variety are shown along with stereophonic sound. The theater has a maskless screen with an illuminated surround which changes brightness with the intensity changes in the picture.

The Motion Picture Research Council in Hollywood has described its work on the investigation of stereoscopic motion pictures stating that thus far the major producers have not used the presently available systems on anything but a novelty basis. These systems have been described in various articles and papers.[3-8]

An announcement was made that Arch Oboler will start soon on a "three-dimensional" film in Hollywood which will utilize the Natural Vision Process for both taking and showing.[9] In this process the pictures are photographed with two synchronized cameras. They are projected with two synchronized projectors having polarizing filters over the lenses and are viewed with Polaroid spectacles. The system will require four projectors for a full-length feature, or for production to be made in such a way that special intermissions may be used for rethreading. It was stated that either film may be used for two-dimensional showing. Demonstration films have been exhibited to invited groups by M. L. Gunsburg who is the head of the Natural Vision Process.

An interesting development during 1951 has been the formation in Great Britain of a new company known as High Definition Films Limited, whose object is to develop electronic camera and kinescope recording equipment suitable for use in film studios for pro-

Submitted, April 22, 1952, at the Society's Convention at Chicago, by Charles W. Handley, Committee Chairman.

duction of first-feature films. The intention is to use a television camera to record the scene on a pickup tube, this picture then to be photographed on motion picture film in the conventional manner. It is planned to develop equipment having a sequentially scanned 900-line picture in order to obtain the necessary quality. The company is staffed largely by engineers recruited from The British Broadcasting Corporation television service and is headed by Norman Collins who was until recently Controller of B.B.C. Television. Initial development work on the necessary equipment is planned to take two years. The company hopes to rent equipment to studios requiring it for production purposes. The proposals outlined by High Definition Films Limited have met with a mixed reception from the film industry and it remains to be seen to what extent they will be accepted.

The Naval Photographic Center successfully completed the experimental utilization of television equipment to produce a motion picture training film. Employing television cameras and television studio techniques, the motion picture negative was exposed by kinescope recording. Sound was simultaneously recorded on a standard film recorder. Composite prints from these negatives were distributed in the usual manner and are adequately fulfilling the requirements of a Navy training film. From the Navy's point of view, the production work load does not appear to warrant employment of such equipment at this time. In time of full mobilization, when production time must be greatly shortened, it is probable that serious consideration will be given to the production of Navy training films with television equipment.

Motion pictures on tape have been listed as a possibility for practical future use.[10] Several people are reported to be working on magnetically recorded motion pictures in which no optics are used in the electronic "camera." It is claimed that a demonstration was made whereby the picture was recorded on a $\frac{1}{4}$-in. magnetic tape from a home television reception of a motion picture film being televised. Images in the rebroadcast were fuzzy but comparable to results obtained with early TV receivers.

Additional television equipment has been installed in theaters throughout the country. These installations include both the direct projection system and the intermediate system. Considerable publicity has been released on the Swiss Eidophor system which was mentioned in the Progress Report of 1950. Preliminary demonstrations for the press and motion picture industry people were conducted in Zurich during mid-November 1951. Preparations are now being completed for early demonstrations in New York.

Color Processes. At least three studios are equipped to do all or a part of color processing on a limited number of full-length color features.[11]

Consolidated Film Industries report additions and new equipment for color processing which enable them to handle the various negative-positive color processes and also to make 35mm theater release prints from 16mm Kodachrome originals, as well as 16mm color reductions on Kodachrome from 35mm Eastman color negative.

Pathe Laboratories, Inc., have also installed equipment for the handling of color processes and additional auxiliary equipment is being built.

Cinecolor Corporation has stated that its processing capacity for color coupling films has doubled during 1951. Also that SUPERcineCOLOR processing has been set up in the Cinecolor (G.B.) laboratory in England.

It was reported that an increasing demand for color film was noticeable during 1951 in Great Britain, but shortage of suitable raw stock reduced the actual footage used. Technicolor

Table I. Releases on Various Color Processes.

Picture	Studio	Negative Type	Positive Type
Greatest Show on Earth	Paramount	Technicolor 3350 K Balance	Technicolor
Golden Girl	20th Century-Fox	Technicolor 3350 K Balance	Technicolor
The Belle of New York	M.G.M.	Technicolor 3350 K Balance	Technicolor
The Lion and the Horse	Warner Bros.	Eastman	Eastman
The Wild North	M.G.M.	Ansco	Ansco
Honey Chile	Republic	Eastman	Du Pont
Jack and the Beanstalk	Warner (Release)	Eastman	SUPERcineCOLOR

and Gevacolor were the only 35mm processes available.

Changes in color sensitivity of the Technicolor process from a white-light balance to a color-temperature balance of 3350 K has been accomplished and the majority of Technicolor pictures now in production are being made with that system. The camera filter arrangement is changed when shooting with white light on interiors or when shooting exteriors.

Table I shows some of the pictures now in release which were made on the various negative-positive color processes.

The J. Arthur Rank Organization in Great Britain have adopted Ektacolor sheet film for preparing stills for back projection. The scene is photographed on a 5-in. × 4-in. Ektacolor negative and then reduction-printed on Ektacolor positive to a size 3 in. × 2.2 in., which is required for the back projection slide.

35mm Photography

A new synthetic base for photographic film has been developed by the Du Pont Company.[12,13] Greater toughness and dimensional stability are claimed for this than for other types of safety base film. Two years will be needed to complete large-scale manufacturing facilities.

In England the J. Arthur Rank Organization are reported to have used an improved traveling-matte system on a large number of pictures. This process, designed for monochromatic photography, involves the use of a special beam-splitter camera and special colored lighting. The process can be used on almost any subject and does not suffer from the limitations imposed by subjects such as smoke, fine detail, reflections in glass, etc.

Lighting Equipment and Techniques. The change in color sensitivity of the Technicolor process from a white-light to a color-temperature balance of 3350 K has brought about a large increase in the use of incandescent lamps on that system. On small sets and in places where the light from the incandescent lamp is adequate, the illumination may be largely, or entirely, from the incandescent tungsten sources. It is possible to use this system on either a 3350 K balance or a white-light balance by changing the filter arrangement at the camera. During the introduction of the system the incandescent lamps were left unfiltered and the carbon arcs used for effect lighting were filtered to the lower balance. Recently some directors of photography have been reverting to a white-light basis and filtering the incandescents for certain large-area sets like a theater shot in which follow-spots are used, or a night exterior.[14]

The foregoing changes have brought the 10-kw incandescent lamp back into

Fig. 1. Paramount 5-kw incandescent remote-control lamp.

use as well as a unit which is known as Type T-5.[15]

The Paramount Studio's engineering department has developed a remote-control lighting system for use with incandescent lamps (Fig. 1). With this system, lightweight units mounted in various places may be moved at almost any angle, or the focus changed by motor control from a remote master station.[16] The system was designed for use on a circus picture where the lamps had to be mounted on the tent poles; however, it is being adjusted with the thought of bringing studio lighting to an automatically controlled operation insofar as possible. At the time of this writing only the one studio had built any of these motor-drive-controlled units.

Cameras and Accessories. Details of a new combination aerial combat-reconnaissance camera have been announced by the Bell & Howell Co.[17] It is a lightweight, portable, 35mm motion picture camera designed to Air Force specifications by the company in cooperation with Air Force engineers.

35mm Sound Recording

The report on progress in sound recording deals almost entirely with developments in magnetic recording.

Those motion picture producers who had started the conversion of their plants from photographic to magnetic recording during 1950 completed the change-over during 1951, with the result that by the end of last year approximately 75% of the original production recording, music scoring and dubbing in Hollywood was being done on magnetic recording equipment.

Magnetic recording has also found wide use in western continental Europe. For motion picture recording both 35mm and $17\frac{1}{2}$mm films are used. In England the adoption of magnetic recording facilities by studios during 1951 proceeded with considerable caution. It was reported that British Lion Studios at Shepperton are installing five magnetic conversion kits for their Western Electric photographic recorders and Associated British Picture Corporation at Elstree are planning to install five channels of RCA $17\frac{1}{2}$mm magnetic sound equipment.

As a result of experience with magnetic recording during the year, economies anticipated in 1950 were realized in 1951. Through the use of equipments designed to record three tracks on the one strip of film, very worth-while reductions in storage-vault requirements were made and the cost of dubbing domestic and foreign versions was materially reduced.[18, 19]

At the Columbia Studios, storage-vault requirements were reduced by a ratio of better than ten to one and the cost of dubbing foreign versions at this same studio was reduced two to one.

By the use of magnetic equipment on

original production recording, great savings have been effected in the quantity of photographic film used by the industry. This stems largely from the dractices of transferring only choice takes from magnetic to photographic film for dailies and for editing purposes.

A number of problems have arisen during the year connected with the use of magnetic film, one of the most serious of which has been the problem of editing.[20] A number of solutions have been offered, some of which have been adopted with varying degrees of success. Among the solutions, the following may be listed as having the most promise:

1. Magnetic recordings may be transferred to negative photographic film from which prints are made.

2. They may be transferred to direct-positive photographic film which can be used for editing and re-recording.

3. The transfer may be made to a film carrying both photographic and magnetic media.

4. The magnetic material itself may be edited.

The problem of editing the magnetic material itself remains one of the most difficult, and while several designs of editing and splicing equipment have been made, it appears that a satisfactory magnetic film splicer and splicing techniques still remain to be produced.

Paramount Studios report that their magnetic recording program has now been extended to the first phases of magnetic sound editing, and that striped magnetic prints are now replacing direct-positives for this purpose.

Columbia Studios have introduced during the year a combination magnetic and photographic print for editing.

Warner Bros. Studios transfer all magnetic recordings to direct-positive for dailies, for editing purposes and for previews.

Another problem which has received considerable attention during the year has been that of magnetic head wear. Much thought and attention has been given to this problem and solutions appear in the design of magnetic recording heads of harder materials or in the plating of existing heads with some wear-resisting material such as chromium. The latter solution has been adopted by Columbia Studios. It is probable that this particular solution, however, will be superseded as newly designed heads appear and the expensive procedure of removing heads, replacing them in correct alignment and putting them through the plating process will be discarded.

In the use of triple-track recording equipment, problems of crosstalk between tracks and of complete erasure of all three tracks appeared and were solved during the year.

New magnetic recording equipments emerged from the design to the production stage during the year 1951. Among these may be listed a portable magnetic recorder manufactured by RCA for Warner Bros. Pictures, Inc. (Fig. 2), which records a magnetic track on $17\frac{1}{2}$mm film and operates at a speed of 45 fpm.[21] The use of this film width and film speed constitutes a fourfold saving of film cost compared to the single-track magnetic recordings made on 35mm film operating at 90 fpm. Also manufactured by RCA during 1951 and put into service at Warner Bros. was a direct-positive recording optical system using a variable-area Class A push-pull type of sound track. In addition to providing a positive-type sound track, this system also provides anticipatory noise reduction.

Two new magnetic recording and reproducing systems were introduced to the motion picture and television industry in 1951 by Westrex Corp. The 1100 Portable Magnetic System, which is contained in two units, provided for high-quality recording or reproduction with 35mm, $17\frac{1}{2}$mm or 16mm film in synchronism with picture. New features of this system include two-way talk-back between the mixer and recordist, a

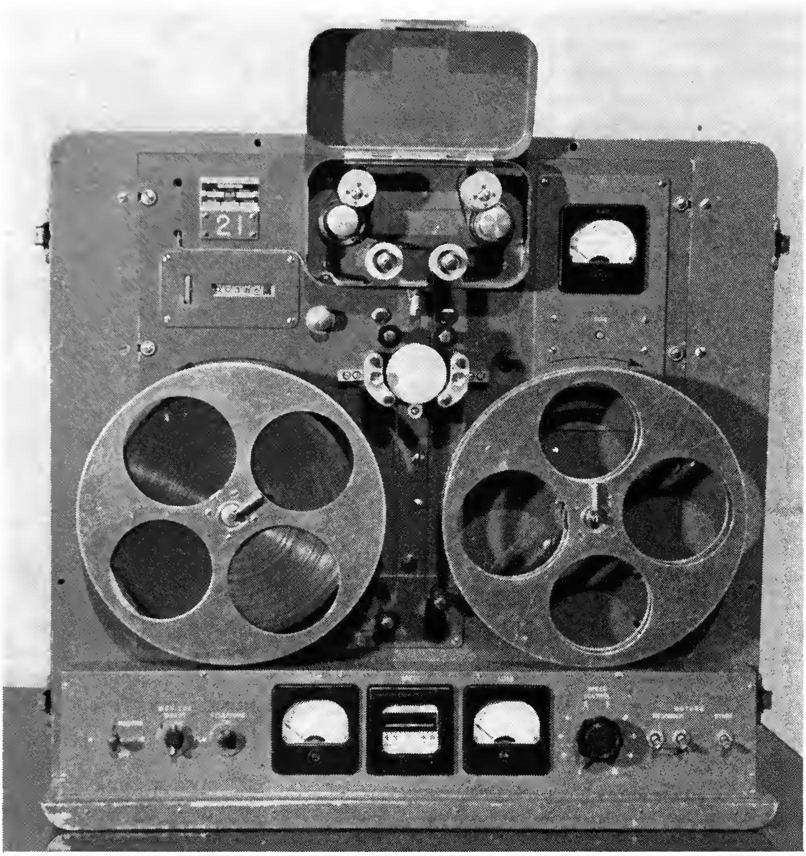

Fig. 2. RCA portable 17½mm 45-fpm magnetic recorder. (Courtesy of Warner Bros. Pictures, Inc.)

new synchronizing bloop unit which records an audible signal on the magnetic film in synchronism with an optical bloop when the recorder is up to speed and it is designed for operation with synchronous, interlock or multiduty motor systems.

The Westrex RA-1506-A Recorder shown in Fig. 3 is a cabinet-mounted equipment containing three independent recording and reproducing channels. Crosstalk from adjacent tracks is kept to a level of −60 db by the introduction of magnetic decouplers in the multiple-head structure.

Tape recording of sound made several gains in 1951. There was substantial improvement in the magnetic tapes available with respect to both mechanical and electromagnetic qualities. There were general improvements in the machines available both in the home and professional fields. Tapes operating as low as 1 in./sec that reproduce voice quality have been demonstrated. There is a trend toward lower tape speeds with 7½ in./sec becoming more important to broadcasters. Fifteen inches per second is becoming common for

high fidelity, with 30 in./sec in use only in a few places for such work as master recordings. Tape duplicating service has been announced where several copies can be made from one original at several times normal recording speed.

In the manufacture of magnetic recording materials, considerable emphasis has been placed on uniformity of coating and the proven results of roll-to-roll uniformity have aided in the acceptance of magnetic recording as the number one recording medium. A significant contribution was made during the past year by the Reeves Soundcraft Corp. through its commercial introduction of 16mm and 35mm film having magnetic stripes for magnetic recording. After two or three years of development work, its availability on a commercial basis was finally announced in February 1951. Magnetic striping can also be added to a customers photographic film which has already been processed.

Some progress was made during the year toward standardization of magnetic track position and track width in 16mm, $17\frac{1}{2}$mm, 35mm and striped 16mm and 35mm films. However, as of the present date, no final standards have been adopted and much work remains to finally settle this debatable issue.

Temporary frequency azimuth test films have been made available. Final versions of these test films, theater test films, and azimuth test films, covering the full width of the film to accommodate any track position, are at present in work.

The Armed Services are making ever-increasing use of magnetic recording and it is reported that they have used over one million feet of striped film on which the magnetic striping covers one-half of the photographic sound track. These films are used where it is necessary to record information in a foreign language and still have the English version available for reproduction.

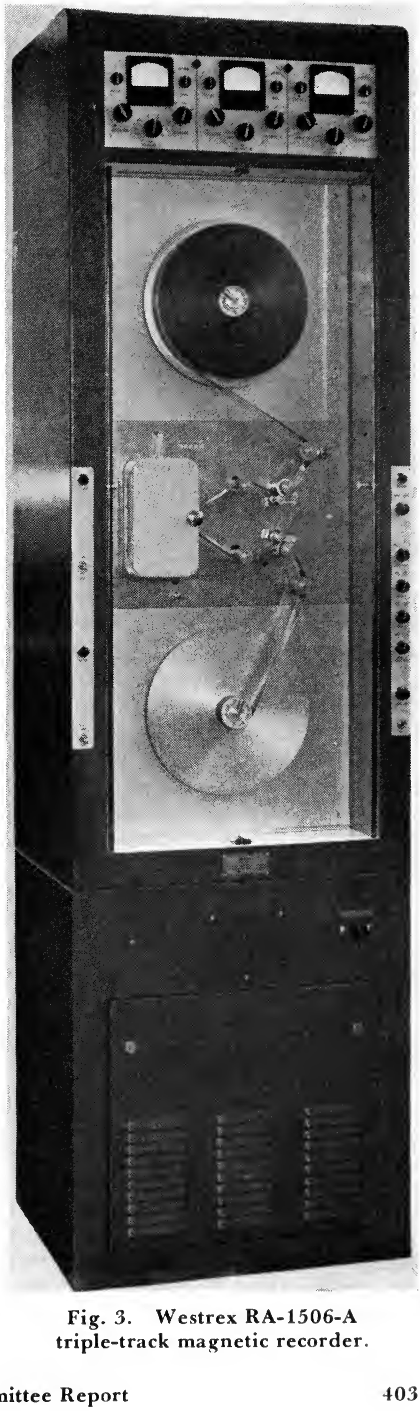

Fig. 3. Westrex RA-1506-A triple-track magnetic recorder.

To divert from the field of magnetic recording, the Eastman Kodak Co. introduced during the past year the Eastman high-speed positive safety film Type 5305. This is a film having the high speed of Eastman sound recording film Type 1357 and the finer grain of Eastman release positive film Type 1301, both of which the new film supersedes.

The results of a study of the technique of making sound-track prints on Eastman color print film Type 5381 were reported.[22,23]

16mm Photography and Sound Recording

In the field of 16mm recording, new equipments have been introduced by both RCA and Westrex. A number of 16mm magnetic recorder-reproducer equipments (PM-66), operating at 36 fpm and capable of being electrically interlocked with 35mm cameras or projectors, were manufactured by RCA.

A 16mm photomagnetic re-recorder, manufactured by Westrex Corp. (Type RA-1509-A), is a cabinet-mounted equipment which provides facilities for recording and reproducing magnetic sound track and for reproducing photographic sound track at synchronous film speed.

Berndt-Bach Corp. of Hollywood has built a new 16mm professional-type camera which provides for a maximum of 1200 ft of film and is known as the "Super-1200." It is a sound-on-film type and is reported to run so quietly that no external blimp is required (Fig. 4).[24]

Both Consolidated Film Industries and Pathe Laboratories, Inc., in Hollywood have provided for new building facilities for the developing and printing of 16mm film. These new facilities reflect the widespread demand for 16mm prints in the educational, religious and commercial fields, together with the increasing demands of the television industry.

The Air Force has developed a system of three-dimensional motion picture photography and projection employing a Polaroid method for right and left picture selection. 16mm high-speed, normal-speed and time-lapse stereoscopic color motion pictures have been demonstrated which used a single projector equipped with a synchronizing drum polarizer in front of the lens and a Morgana-type shuttle mechanism.[4]

Third-dimension converters for 16mm cameras have been described. The camera and projector converters, screen, and Polaroid glasses are being sold as a package unit by the Nord Company of Minneapolis (Fig. 5).[25]

A prototype of an automatic-loading motion picture camera has been designed and produced for the Naval Photographic Center by G. J. Badgely. The insertion of the magazine causes the feed and take-up sprockets of the camera to rotate, automatically picking up predetermined lengths of film, and forming the film into loops before and after the picture aperture. In its development for television recording, the camera uses a single motor to drive the mechanism. Stabilization of the shutter is accomplished by a combination of slipping rim and hysteresis drag. Provisions are made to observe and correct shutter banding while the camera is in operation.

The Naval Ordnance Laboratory has employed the image phototube as a high-speed camera shutter. Having a greater efficiency than the Kerr cell, a light gain is possible. The angle of view is governed entirely by the lens system used.

The Springfield Arsenal has designed a slide rule for analyzing high-speed motion picture data. It performs several basic calculations which must be repeated often in the evaluation of high-speed photography in mechanics research. It permits more rapid calculations with fewer errors and with less highly trained personnel.

Fig. 4. New Auricon "Super-1200" 16mm professional camera.

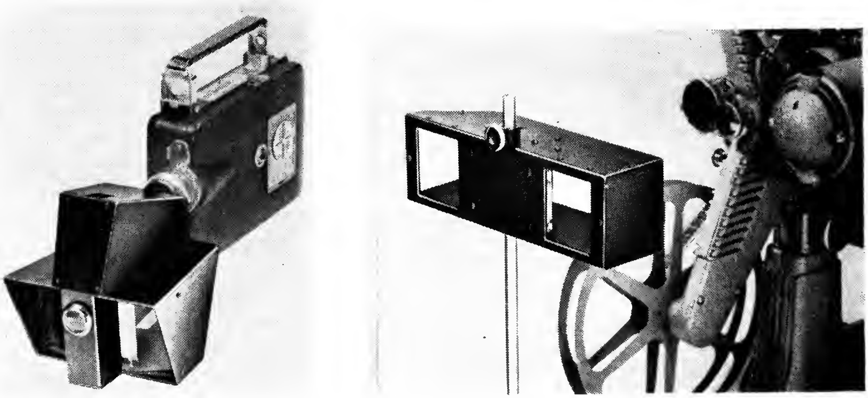

Fig. 5. Nord third-dimension converter for any 16mm camera and projector.

35mm Picture and Sound Reproduction

Means of removing heat from film in projection is still receiving considerable attention. Interference-type heat filters and mirrors have been written about and tested, heat-absorbing glass filters, compressed air from jets and water-cooled aperture plates are in use on different types of projectors.[26–30]

There has been a renewed interest in maskless screens and illuminated borders. Several theaters have installed maskless screens. At the Telecinema at the Festival of Britain the surround changes intensity with changes in screen light.[2, 31–33]

A considerable portion of the September 1951 issue of the *Journal* was used for papers relating to screen brightness and viewing conditions. A further report on screen brightness discussed screen light distribution.[34]

16mm Picture and Sound Reproduction

Important in the field of 16mm sound reproduction is the introduction by a number of manufacturers of models designed to play magnetic and photographic recordings.

The new RCA "400" dual-purpose projector makes possible the recording of magnetic sound on processed 16mm films without studio facilities. It also projects sound films having optical tracks. It opens up wide possibilities for nonprofessional sound-film makers.[35]

Bell & Howell introduced a 16mm magnetic recorder-projector, Filmosound Model 202, which will record sound on 16mm films, also play back either optical or magnetic sound tracks interchangeably. The company has also introduced its own sound striping service (Fig. 6).[36]

Television

Even though seriously handicapped by the Federal Communication Commission's freeze on the construction of new television stations, television as an industry has enjoyed fantastic growth during 1951. One of the largest networks is reported to be a very close second to *Life Magazine* in paid advertising income. Even more startling is the advance made in the manufacture of television receivers and accessories. The industry is now one of the leading manufacturing activities in the country and 1951 sales were in excess of $1\frac{1}{2}$ billion dollars.

In the annual report recorded in this *Journal* last year, comment was made on the increase in quality of programming produced by the television networks.[37] This trend has continued and now it is common for a single television show to be budgeted as high as $75,000. Such large budgets are justified on the basis of increased live coverage now available to the networks. The microwave relay and coaxial cable system has been considerably extended during the year. On September 4, 1951, the first transcontinental television program was broadcast on the occasion of the Japanese Peace Conference.

There has been a marked increase in the use of theater television during 1951. Sporting events and other special events have been delivered to theater audiences on an exclusive basis. The increased use of theater television has been responsible for reduction of the cost of equipping theaters for this purpose, thus giving added impetus to this phase of the industry. The final growth and development of theater television is, like many phases of the business, controlled to some degree by the Federal Communication Commission. Much discussion has taken place during the year on specific allocations to be used for relaying television pictures from theater to theater and from city to city. These discussions are still active and will undoubtedly continue through a portion of next year.

Although the backbone of television so far has been based on black-and-white pictures, color television has re-

Fig. 6. Bell & Howell Filmosound Model 202, 16mm magnetic recorder-projector.

ceived considerable attention during 1951. The prolonged FCC hearing on this subject was concluded on October 25, 1951. In spite of this activity in the color field, the commercialization of color is still in the future and is beset with numerous complications, not only regulatory and economic, but also in terms of equipment design and manufacture.

Film, both direct and in the form of video recordings, has continued to be a major source of programming for many television stations. The networks have produced thousands of feet of recordings and, in addition, many independent film companies have been active in the production of special features for the industry. Great progress has been made in controlling the cost of these special features and at the same time retaining acceptable quality for television broadcasting.

Video recording is still largely done on 16mm stock. There is some trend, particularly in larger stations, toward the use of 35mm for such recording because even though the television system is limited, on account of the standards which have been adopted, 35mm equipment can produce demonstratively better recording quality.

With the opening of the transcontinental microwave relay for television, the Hollywood television studios were confronted with a three-hour time differential between the East Coast and West Coast. Programs originating in the East at 8 P.M., for example, would be available at the West Coast at 5 P.M., a time when most people would not be able to view the program. Accordingly

35mm kinescope recording and processing facilities were set up to handle a half-hour show of 3000 ft of film per reel.

Television in France is about where it was in America five years ago. There are regular daily transmissions from Paris and Lille by the Radiodiffusion and Television Francaises which is government owned and is directed by the Ministry of Information. The programs are largely five-year-old films, live studio sketches and stage plays, a daily newsreel, and a weekly newsreel from twenty years ago. This is partly financed by an annual license fee due on each receiver equal to about ten dollars. It is estimated that there are about 50,000 receivers in operation.

In Belgium, Holland, Germany, Switzerland and Spain there are experimental transmissions by private interests. In Italy there are regular broadcasts from the Vatican.

There is some divergence between the signal characteristics used. France uses a provisional low-standard 441 lines, as well as high-definition 819 lines. The 441 lines is scheduled to be abandoned in 1961. The other countries are tending toward the Dutch and German standard of 625 lines. Fifty cycles per second interlaced vertical scanning is used by all. Video modulation here is positive, so that white corresponds to rf modulation peaks, and sync pulses to rf minimums. The radio-frequencies in use at present are 40–50 mc for London and low-definition France, and 175–190 mc for the high-definition. London of course uses 405 lines.

There is one microwave radio relay link between Paris and Lille, and several others under study in France and Italy.

References

1. Alfred Gilks, "Some highlights in the filming of *An American in Paris*, *Am. Cinematographer*, *33:* 18, Jan. 1952.
2. A. Bowen, J. Moir and H. Turner, "Projection in Britain's 'Telekinema,' " *Intern. Projectionist*, *26:* 11, Oct. 1951. *See also:* Raymond Spottiswoode, "Progress in three-dimensional films at the Festival of Britain," *Jour. SMPTE*, *58:* 291–303, Apr. 1952.
3. W. F. Kelley and W. V. Wolfe, "Technical activities of the Motion Picture Research Council," *Jour. SMPTE*, *56:* 178–196, Feb. 1951.
4. R. V. Bernier, "Three-dimensional motion picture applications," *Jour. SMPTE*, *56:* 599–612, June 1951.
5. J. A. Norling, "Stereoscopic motion pictures," *Intern. Projectionist*, *26:* 12, Aug. 1951.
6. J. A. Norling, "Stereoscopic motion pictures," *Am. Cinematographer*, *33:* 66, Feb. 1952.
7. Norman McLaren, "Stereographic animation," *Jour. SMPTE*, *57:* 513–520, Dec. 1951.
8. J. A. Norling, "Stereoscopic motion pictures," *Intern. Projectionist*, *27:* 9, Feb. 1952.
9. "Plan a stereo feature picture via 'Natural Vision' process," news item, *Intern. Projectionist*, *27:* 22, Feb. 1952.
10. Frederick Foster, "Motion pictures on tape," *Am. Cinematographer*, *32:* 500, Dec. 1951.
11. Arthur Rowan "*The Wild North* introduces MGM's new Ansco Color process," *Am. Cinematographer*, *33:* 106, Mar. 1952.
12. "Keeping up with photography," news item, *Am. Cinematographer*, *33:* 8, Jan. 1952.
13. "Du Pont's new 'thin' film related to 'Dacron' fiber," news item, *Intern. Projectionist*, *27:* 10, Jan. 1952.
14. W. W. Lozier and F. T. Bowditch, "Carbon arcs for motion picture studio lighting," *Jour. SMPTE*, *57:* 551–558, Dec. 1951.
15. R. G. Linderman, C. W. Handley and A. Rodgers, "Illumination in motion picture production," *Jour. SMPE*, *40:* 333–367, June 1943.
16. Arthur Rowan, "Set lighting by remote control," *Am. Cinematographer*, *32:* 444, Nov. 1951.
17. "New combat reconnaissance camera," *Am. Cinematographer*, *32:* 280, July 1951.
18. C. C. Davis, J. G. Frayne and E. W. Templin, "Multichannel magnetic film recording and reproducing unit,"

Jour. SMPTE, 58: 105–118, Feb. 1952.
19. Ralph Lawton, "The Westrex magnetic film recording systems," *Am. Cinematographer, 32:* 182, May 1951.
20. Loren L. Ryder, "Editing magnetic sound," *Am. Cinematographer, 32:* 137, Apr. 1951.
21. Kurt Singer and H. Connell Ward, "A technical solution of making recording cost reduction," *Jour. SMPTE, 58:* 329–358, Apr. 1952.
22. C. H. Evans and J. F. Finkle, "Sound track on Eastman Color Print Film," *Jour. SMPTE, 57:* 131–139, Aug. 1951.
23. J. G. Streiffert, "Radial-tooth variable-pitch sprocket," *Jour. SMPTE, 57:* 529–550, Dec. 1951.
24. Frederick Foster, "The new Auricon 'Super-1200,'" *Am. Cinematographer, 32:* 223, June 1951.
25. John Forbes, "Stereoscopic movies with any 16-mm camera," *Am. Cinematographer, 33:* 72, Feb. 1952.
26. "Interference mirrors for projection," news item, *Intern. Projectionist, 26:* 17, Apr. 1951.
27. Charles Hahn, "The trail of the elusive lumen," *Intern. Projectionist, 26:* 5, Nov. 1951.
28. G. L. Dimmick and M. E. Widdop, "Heat-transmitting mirror," *Jour. SMPTE, 58:* 36–42, Jan. 1952.
29. Hugh McG. Ross, "The cooling of film and slides in projectors," *Jour. SMPTE, 56:* 538–550, May 1951.
30. Robert A. Mitchell, "An object lesson in film-cooling," *Intern. Projectionist, 27:* 5, Feb. 1952.
31. "Maskless screen steadily gains favor," news item, *Intern. Projectionist, 26:* 10, June 1951.
32. "Latest maskless screen wins audience, technician favor," news item, *Intern. Projectionist, 26:* 14, Oct. 1951.
33. "To mask- or unmask," editorial comment, *Intern. Projectionist, 27:* 16, Jan. 1952.
34. W. W. Lozier, "Further report on Screen Brightness Committee theater survey," *Jour. SMPTE, 57:* 489–493, Nov. 1951.
35. Ralph Lawton, "Dual-purpose projector," *Am. Cinematographer, 32:* 450, Nov. 1951.
36. E. C. Hajduk, "Bell & Howell introduces 16-mm magnetic recorder-projector," *Am. Cinematographer, 33:* 112, Mar. 1952.
37. C. W. Handley, "Progress Committee Report," *Jour. SMPTE, 56:* 568–583, May 1951.

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Magnetic Print-Through—Its Measurement and Reduction

By LYMAN J. WIGGIN

A simple dynamic method of measuring the value of print-through and then a method of reducing it below audibility by application of a supersonic erase bias during playback are described.

MAGNETIC RECORDING is today's nearest approach to perfection in sound recording and reproduction, especially with the use of quarter-inch tape. However, there is one flaw in this "near-perfect" method which, in some instances, makes it unacceptable. This problem is magnetic print-through, which causes echoes to be heard preceding or following a signal. This is caused by the magnetic field, which surrounds the recorded signal, magnetizing the coating on adjacent turns of the roll of tape. In a typical tape application using 2500-ft rolls at a 15-in./sec speed, adjacent turns are played at intervals of from 1 to 2 sec. In certain types of recorded sounds, particularly voice with no background, there are frequent pauses of sufficient duration where the print-through can be audible enough to be annoying. Unfortunately the loudest print-through comes just before the signal, giving a pre-echo which is never found in natural sound and so is not accepted by the ear to the same extent as a post-echo. It is also very damaging to certain dramatic effects and to music, particularly loud chords following rests where the effect is lost by the warning given by the pre-echo. These spurious signals have been termed print-through.

Reeves Sound Studios encountered this problem shortly after installing an elaborate system of making all original recording on Fairchild "Pic-Sync" quarter-inch tape recorders. Intensive research was initiated to see what could be done to solve the problem.

The first tests tried involved listening to recorded 1000-cycle pulses under various test conditions, changing the monitor system gain for each test to get either the same audible level of print-through or just not any, and then comparing the monitor system gains. This method proved to be unsatisfactory and inconclusive.

It was realized that some positive means of measuring the quantity of print-through had to be found. The quantity of print-through that could be tolerated had to be determined also.

Presented on October 18, 1951, at the Society's Convention at Hollywood, Calif., by Edward Schmidt for Lyman J. Wiggin, Reeves Sound Studios, Inc., 10 East 52 St., New York 22, N.Y.

Permissible Amount of Print-Through

In order to find out how much print-through could be tolerated, a tape with male and female voices recorded on it was reproduced in a studio. The monitor system gain was adjusted so the acoustic level was as loud as the loudest level ordinarily used for that studio. Then the channel system gain was reduced by known amounts of attenuation until the reproduced signal was just inaudible. This was found to be about at the point where 55 db of attenuation was used.

This same experiment was carried out in a different studio with different personnel conducting the experiment. The result was the same.

Thus, the maximum print-through value which could be tolerated was 55 db below 100% program level. This figure was later corroborated very closely by production department observations.

Method of Recording a Print-Through Test

The following dynamic method of measuring the quantity of print-through was developed as a fast and direct method. A roll to be tested is completely erased before this test is made. A 2500-foot roll of tape is used. This has an outer diameter of about 10 in., and at 15-in./sec tape speed the supply spool turns about once in 2 sec. Pulses of 1000-cycle tone at 100% level are recorded at intervals. These pulses are long enough for the supply spool to turn $\frac{3}{4}$ revolution, about 1.5 sec. The pulses are repeated every sixth revolution of the supply spool, and generally ten such pulses are sufficient for measurement purposes.

After the recording, the roll is rewound and put in storage for a definite period of time. At Reeves Sound Studios a period of four hours has been selected as a standard storage period.

Method of Measuring a Print-Through Test

In measuring, filters must be used to eliminate or limit any hum or other noise from the tape machine output at the meter on which measurements are to be made. This meter must have means for quickly changing its sensitivity over a wide range and must have a fast-acting pointer movement.

A bandpass filter effect can be achieved by using the 500-cycle high-pass filter and 2000-cycle low-pass filter of a standard Effects Filter. The V.U. meter of a General Radio Type 1932-A Noise and Distortion Meter is used for the indicating instrument. This meter has interlocking push buttons to change sensitivity and meets all the requirements perfectly.

On reproduction, the print-through pulses can be observed rising above the noise level. With recorded pulses every sixth revolution of the supply spool, consider the first print-through observed as the one following a recorded signal. The next will be the second print-through from this signal. The next will be the combination of third print-throughs from the previous signal and the next one coming up. The next will be the second print-through from the signal coming up. The next, always the highest in value, will be the first print-through from the signal coming up. An example of this is shown in the readings below of an actual print-through test. These figures are all in db below the 100% recorded 1000-cycle pulses.

$55\frac{1}{2}$ db—1st print-through after the signal
61 db—2nd print-through after the signal
$61\frac{1}{2}$ db—3rd order print-through
58 db—2nd print-through before the next signal
$51\frac{1}{2}$ db—1st print-through before the next signal

Note: Noise level was 63 db below 100% signal in this test.

We now have a measure of how much print-through reduction is required, as well as a positive and simple method of measuring.

Many experiments were made with little or no results. These experiments included tape with thicker base, cold storage of tape, recording at lower levels and change of recording bias, using a narrower playback head to eliminate any edge effect and using special tapes.

One method of print-through reduction stood out as being practicable without suffering too much from the "inevitable compromise." This method consists of actually erasing the print-through just prior to the program reproduction at the playback head or at least erasing enough of it to make the remaining amount inaudible. If print-through is caused by inclusion of very easily magnetizable fractions in the coating and is mainly a surface effect, then threshold erase is a solution.

The following paragraphs and tables are the final results of what seems to be a positive method of eliminating trouble due to audible print-through, at least with the Fairchild "Pic-Sync" machines.

Print-Through Erasing

Although the application of some surface erasing seems to eliminate audible print-through, complete tests had to be made to see if any other trouble was being introduced in the reproduction of program material.

In all the tests that follow, the recordings were made in the normal manner described before. In the reproduction of these tests the following changes were made to the Fairchild Machine:

1. The record head plug was removed from its receptacle.

2. The erase head plug was inserted into the record head receptacle. This connects the erase head to the normal record head circuit.

3. A 3700-ohm resistor was added in series with the present 2200-ohm V.I. meter bridging-out resistor for the reading of bias. This allowed a reading of bias to the erase head of 0.5 db which corresponded to a Ballantine VTVM reading of 16.5 v across the erase head and 3.5 v across the 130-ohm resistor normally in series with the record head.

4. The relay coil circuit in the power amplifier chassis was opened so the 14,000-cycle control signal would not be applied to the record head receptacle to which the erase head is now connected. This was necessary to avoid loss of synchronization on playback.

The above changes put what was normally the 69,000-cycle recording bias into the erase head instead. The value of this bias is adjustable with its usual control.

The first test made was to see what happened to frequency response with erasing before playback. A complete frequency test was recorded 10 db below 100% signal level in a normal manner. It was reproduced immediately in a normal manner. Then it was immediately reproduced three more times with 69,000 cycles to the erase head each time. The results are shown in Table I. They

Table I. Frequency Response, in db.

	69,000 cycles to erase head			
Frequency	Off	On 1st reprod.	On 2d reprod.	On 3d reprod.
30	0	+0.1	+0.1	0
40	0	+0.1	+0.1	0
50	0	+0.1	+0.1	+0.1
70	0	0	0	0
100	0	0	0	0
200	0	0	0	−0.1
500	0	−0.2	−0.2	−0.2
1,000	0	−0.3	−0.3	−0.3
2,000	0	−0.3	−0.3	−0.3
3,000	0	−0.4	−0.4	−0.4
4,000	0	−0.4	−0.4	−0.4
5,000	0	−0.5	−0.6	−0.5
6,000	0	−0.5	−0.5	−0.5
7,000	0	−0.5	−0.5	−0.5
8,000	0	−0.5	−0.5	−0.5
9,000	0	−0.5	−0.5	−0.5
10,000	0	−0.4	−0.5	−0.5
11,000	0	−0.5	−0.5	−0.5
12,000	0	−0.6	−0.6	−0.6
13,000	0	−0.6	−0.5	−0.6

Note: Correction applied to all readings so normal playback response shows flat.

show two important things: first, a slight loss in high frequencies (the only compromise found so far); and second, immediate repeated playings have no more effect. These effects can be explained by assuming that the erasing being done is only on the tape surface. The higher frequencies, occupying less depth in the magnetic coating, had a higher proportion of their signal erased, and after the surface is erased once, there is no more effect, at least for immediate repeated playings. Final tests have not been made to determine what happens if this same roll is stored a while and then reproduced again in a like manner.

The above test was repeated using rolls from three tape manufacturers, except that the repeated playings with the 69,000 cycles were considered unnecessary. The results showed no appreciable differences. However, it is quite conceivable that recordings made on another machine, other than a Fairchild, could show a difference. Whether or not this could occur would depend on the record head magnetic field distribution and the resulting ratio of frequency vs. depth of magnetization on the tape.

The next test made was for distortion. An intermodulation signal of 2000 and 100 cycles at a 1:4 ratio was recorded, varying the input level in regular steps. The results in Table II show that there is no change at all in intermodulation distortion with the application of 69,000 cycles to the erase head, either during the first playback or for three successive immediate playbacks. This holds true also for tapes of other manufacturers recorded on the Fairchild machine.

The next test made was to see if output level changes would follow input level changes over a reasonable range. The results of this test are shown in Table III. Appropriate high-pass and low-pass filters were inserted in the playback circuit to limit the effect of noise as far as possible, although some radio-television interference was present. With the application of 69,000 cycles to the erase head the

Table II. Intermodulation Distortion, in %.

Input level	69,000 cycles to erase head			
	Off	On	On	On
−4	1.0	1.0	1.0	1.0
−2	1.0	1.0	1.0	1.0
0*	1.3	1.3	1.3	1.3
+2	1.8	1.8	1.8	1.8
+4	2.7	2.7	2.7	2.7
+6	4.0	4.0	4.0	4.0
+8	6.0	6.1	6.0	6.0

* Normal 100% input level.

1000-cycle output dropped about 0.25 db and the 10,000 cycle output dropped about 0.5 db. This is to be expected from the frequency-response results shown in Table I, as the same roll of tape was used. The second and third successive playbacks with the 69,000 cycles to the erase head again show no significant difference from the first playback under the same conditions.

The above test was repeated with tapes of other manufacturers with practically identical results.

A specific test for the effect on noise level of 69,000 cycles applied to the erase head was not made. However, in all print-through tests the noise level showed no change with the restricted frequency range used.

In trying to leave no stone unturned, any possible effect of a subharmonic of the 69,000 cycles applied to the erase head causing trouble was investigated. As any effect of this sort should show up in a frequency-response test, a recording was made 10 db below 100% level of a very slow frequency sweep up and then down from 6000 to 8000 cycles. This sweep included 6900 cycles, the 10th subharmonic of the 69,000 cycles. The total recording time of this test was 2 min and 40 sec. In playing back this recording with the 69,000 cycles applied to the erase head no significant change in output level was noticed at any frequency.

Table III. Output vs. Input Level Change Linearity, in db.

Input level	69,000 cycles to erase head — Variations from reading without 69,000 cycles — Playback at 100 cycles 1st	2d	3d	Playback at 1000 cycles 1st	2d	3d	Playback at 10,000 cycles 1st	2d	3d
0*	−0.1	−0.1	0	−0.3	−0.3	−0.3	−0.5	−0.6	−0.8
−10	−0.1	−0.1	0	−0.4	−0.3	−0.3	−0.6	−0.9	−0.9
−20	−0.1	−0.2	−0.1	−0.3	−0.3	−0.2	−0.4	−0.6	−0.7
−30	−0.2	−0.2	−0.1	−0.3	−0.3	−0.3	−0.6	−0.7	−0.8
−40	0	0	+0.1	−0.2	−0.2	−0.2			
−42	−0.2	−0.1	0	−0.1	−0.1	−0.2	−0.6	−0.5	−0.4
−44	−0.1	−0.1	−0.2	−0.2	−0.2	−0.2	−0.4	−0.4	−0.5
−46	−0.1	0	0	−0.3	−0.3	−0.4	−0.6	−0.6	−0.6
−48	−0.4	−0.2	−0.2	−0.2	−0.3	−0.4	−0.4	−0.4	−0.4
−50	−0.4	−0.4	−0.3	+0.1	0	+0.1	−0.1	−0.2	−0.1

* Normal 100% input level.

The last test was to determine the print-through reduction effectiveness of the 69,000 cycles to the erase head on tapes of three manufacturers. Tape rolls A, B, C and D were put through the regular print-through test routine except that two groups of 1000-cycle pulses were recorded on each roll. The first group on each roll was played back with the machine in its normal condition and the second group with the 69,000 cycles to the erase head. The results are tabulated in Table IV. Accepting the figure of 55 db below 100% signal level as being just satisfactory, tapes A, B and D would reproduce audible print-through under normal reproducing conditions and tape C would not. With the application of 69,000 cycles on the erase head, none of the four tapes would reproduce audible print-through.

Table IV. Print-Through and Noise Level, −db Below 100% Signal

	Tape Roll — Tape A	Tape B	Tape C	Tape D
69,000 cycles, off	53½	49½	57	52½
69,000 cycles, on	59½	56½	61½	59½
Noise level	65	66	63	63

As a result of these tests, the print-through problem (as applied to production methods) appears to be solved. The only compromise in making this possible is a slight reduction in high-frequency response. This effect is small enough to be ignored, but it can be compensated for in the playback amplifier equalization. Reeves Sound Studios have put this system of print-through reduction in operation.

In conclusion I wish to acknowledge the helpful assistance of Raymond E. Biondi, Homer H. Elder, Charles E. Campbell and Richard J. Vorisek of Reeves Sound Studios, Inc.; Ernest W. Franck and Edward Schmidt of Reeves Soundcraft Corp.; and Wentworth D. Fling of Fairchild Recording Equipment Corp.

A Scientific Approach to Informational-Instructional Film Production and Utilization

By C. R. CARPENTER and L. P. GREENHILL

This is a report on a research program sponsored by the military services for the past four years, dedicated to production of 16mm informational films.

THE EQUIPMENT of the motion picture and television industries has been developed to high performance standards and there is continuing effort to make still further improvements. These improvements are the result of scientific research in such fields as physics, chemistry, optics, electronics and engineering. Research and development have been concentrated mainly on technical equipment and its performance.

The primary function of motion picture and television equipment is to communicate from some people to other people. Therefore, the men who use this equipment must deal with human factors which are even more complex than the electronic and optical processes used in recording and reproducing ideas or information on films or television.

Motion picture and television engineers, regardless of their specific technical jobs, are working within a matrix of human factors, processes and variables. The study and control of the interaction between equipment and people, is an area of applied psychology which has been termed Human Engineering.

When we look at the field of communication as a whole it is clear that:

1. We have made great progress in developing mass communication equipment.
2. We have made little progress in scientific research on the psychological processes of communication.
3. Technological developments are far ahead of the human engineering developments.

We have developed wonderful machines and systems for communicating, but we are uncertain how to use them to the best advantage for worth-while purposes. We can communicate with millions of people in this and other countries,

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but we are not sure what should be communicated. Even when we know what to communicate, we do not have confidence in our knowledge of methods for doing this effectively. There are challenging social problems which the communications industries might aid in solving with their available tools, but these tools are not being applied effectively to these problems. The *science* of human engineering as applied to radio, motion pictures and television is in its very early infancy.

We believe that this lack of development is due in large part to the fact that the *human variables* in mass communications have not been thought of as a legitimate and important field for scientific research and development. Consequently this kind of research, both basic and applied, has been grossly neglected. Resources for this kind of work have not been made available: men with adequate competencies have not been trained for the job; suitable research laboratories have not been built.

It is encouraging, however, to observe that there is a growing interest in the human aspects of communications. A few universities are establishing departments of communication. Government and military research organizations are supporting and encouraging research in this field. It is being realized also that "audience research," though important, is not sufficient for learning all we need to know in order to apply intelligently the potential powers of the communication industries to urgent problems of our society: problems of information dissemination, of group and class tensions and conflicts, of instruction necessary for people's adjustment and survival in a complex world of successive crises.

Should it not be that the *primary mission* of the communications industries is that of *training*, *instructing* and *informing* people, and that the amusement and entertainment of people is the secondary mission of these great industries? If this emphasis were to be arranged, these industries would assume a place of paramount significance in our world.

Importance for Engineers

The foregoing considerations are of great importance for motion picture and television engineers. New nonentertainment uses for the mass media are making up a large part of current film production. The need for extending the application of sound motion pictures and television is a matter which challenges promotion, financing and business organization. It is not mere speculation to visualize the possibilities of nonentertainment communications expanding to the point where the volume of business for this purpose will exceed the volume of business for entertainment purposes.

The engineer has a vested interest in the *effects on people* of the programs which he helps produce. For example, the strength of impact of a program calculated to sell products and the ways in which this impact, over a period of time, changes the behavior of audiences may determine whether or not the program will be continued. The engineer's understanding of human engineering factors can have a vital influence on that impact. Furthermore, the intelligent communications engineer has the right and the responsibility to be concerned with the effects of programs on people. If both he and the medium are to have integrity he certainly cannot allow himself to be a mere automaton of the communications machinery. The control of the mass communications industries can be centralized and authoritative or the control can be democratic; that is, it can be dispersed to conform to democratic management which will permit the individual exercise of judgment and knowledge by the engineer in determining the final influence of a motion picture or television program.

Thus, both from the viewpoint of business and of professional-social responsibility, the engineer has a vested interest in the effects of programs on people.

The Instructional Film Research Program of The Pennsylvania State College is one limited effort to learn more about the human factors and the ways they interact with the sound motion picture as a medium of communication. The Program is sponsored by the Departments of the Army and the Navy through the Special Devices Center, Port Washington, L.I., N.Y.

The objective of the Program in terms of the controlling Task Order is to discover facts and principles which will improve the effectiveness of films for the rapid training, instruction and education of large numbers of people.

It is the central responsibility of the Instructional Film Research Program to apply and test the application of learning principles to instruction by motion pictures, as well as to try to develop new principles and procedures for increasing the effectiveness of film-mediated instruction.

Since its beginning in 1947 the research of the Instructional Film Research Program has been limited mainly to the instructional and informational film. The entertainment film has been of interest to the extent that it may involve processes which can be used to improve instructional and informational films.

Research Methods and Procedures

There is nothing obscure or mysterious about the methods and procedures being used in this research. Essentially the methods consist of applying and adapting the general principles of scientific research to the content and arrangement of stimulus variables in instructional motion pictures. Research is done also on the responses of individuals to these film variables. In general, the problem is one of determining the effects on target audiences of varying the streams of stimuli-events channeled through the sound motion picture.

Theoretical concepts are used at many points and in many ways. Existing and generally accepted theories of learning may be tested in a film context. Theoretical hypotheses may be stated as settings for research projects. Theoretical outlines may be used to guide the direction and to help maintain the balance of effort of the continuing program. Finally, theoretical statements may be employed to aid in summarizing and interpreting results. *For the practical man there is nothing so practical and useful as sound, tested theory.*

Usually we proceed by defining the variable which we wish to study in a film. For example, we may define *rate of development* (the screen time devoted to each phase of the action) as the variable to be studied. The next step may be to produce several film versions, preferably three or more, which differ from each other *only* with respect to *rate of development.* These different versions of films are then shown to matched groups of subjects, the amounts of learning are measured, and the results are compared. Thus, we learn which *rate of development* is most effective for the experimental film when used with a particular audience.

Several variables may be combined in a single version. For example, *rate of development* may be combined with controlled *repetition.* By producing systematically a number of experimental film versions, some with and some without specified variables, it is possible to determine the relative contribution of single variables to learning, and also to determine how the variables interact with each other and with the audience. Some variables may be additive in their effects while others may interfere with each other.

An experimental film *variable* is a single, definable, controlled characteristic of a film, such as rate of development, repetition, "subjective" camera

Fig. 1. Class learning tumbling skills from film loops and daylight projector.

angle or level of difficulty of materials presented.

An experimental film *version* is a film which contains the controlled stimulus material (one or more variables) which is presented to a test group of subjects. A number of such film versions varied in systematic fashion may be required for solving a defined problem.

The design of experiments for testing the relative effectiveness of several variables is somewhat complicated. However, there is one clear, simple and important concept, namely the effects of a variable are measured in terms of the responses of the individuals in the test population. For example, if the film's purpose is to teach facts, the central question is: How does the experimental variable contribute to or interfere with the learning of the presented body of facts? The measurement is made by informational tests, usually of the multiple-choice type. The objective is to measure the amount of learning and retention which is the result of the film, and furthermore to measure the increment of learning which results from the presence in the film of the one or more experimental variables.

With experimental films which have as their objective the teaching of performance skills, essentially the same procedures are used, except that actual performance tests are given. The basic questions are: Does the film actually teach the performance of a skill, and how much of this teaching is the result of the experimental variable? Does a film which is supposed to teach first aid to the injured actually teach trainees something in addition to what they already know? If one of the versions contains the experimental variable *showing errors to be avoided* in giving first aid, is this film version superior to one which does not include the variable *showing errors to be avoided?* With

performance-type films the desirable thing is to measure the *actual performance* of the trainees before and after filmic instruction, i.e., to determine whether the performance of a group trained by a film under specified conditions is superior to that of a control group, i.e., an equivalent group not subjected to the filmic instruction.

In brief, the emphasis is on measuring actual changes in the behavior which results directly from the stimulus value of the film and its controlled characteristics.

Research Projects and Results

The Instructional Film Research Program has formulated more than sixty research projects. These projects may be classed into four groups: (1) the development of new research equipment, and testing of new equipment and methods of using it; (2) research on films produced for teaching performance skills of various kinds; (3) research on films for teaching factual information; and (4) research on films for changing attitudes, opinions and personal orientation.

These four general groupings of projects which have been undertaken by the Instructional Film Research Program include many phases of work related to both the producing and the using of sound motion pictures. Many of the research projects are also closely related to basic problems of radio and television as well as to the sound motion picture. Regardless of the research problem or the type of materials used, the basic requirement is *to discover variables of communication which produce desired changes in the behavior (perception, learning, motivation, actions, etc.) of defined target audiences.*

Development and Testing of Equipment

A. The Classroom Communicator and Film Analyzer systems[1,2] have been planned and developed primarily as research tools appropriate to the problems being attacked. However, this equipment may be adapted for a wide range of uses in practical situations where reactions of people to film, radio and television programs are required. Figures 1 through 4 show the general features of these systems.

The Classroom Communicator and Film Analyzer when used together are capable of doing the following:

1. Immediately recording discrete responses of individuals in audiences of up to 40 people in size.
2. Continuously recording reactions, decisions and judgments of individuals while programs are being presented.
3. Rapidly informing either individuals or the group as a whole of the results of their responses, i.e., correctness or incorrectness of choices.
4. Providing summated numerical records of scores for individuals.

B. The Tele-kit. Research was done last year (1951) on field-testing and developing methods of use for the Tele-kit daylight 16mm projector along with the T.A. Repetitive Impact continuous film magazine.[3,4] The equipment for testing was made available to us by Capt. William C. Eddy of Television Associates, Inc.

The purposes of one series of experiments were to determine the functional characteristics and limitations of the equipment, to develop methods and procedures for using the equipment, and to test the amounts of learning of skills induced by methods of instruction using this equipment in comparison with other methods of instruction. Using the film-loop projector alongside the training area, and providing for interspersed practice was found to be a very effective method of teaching physical performance skills.

Further research[5] was conducted at The Great Lakes Naval Training Station to study the following problems relating to the use of the Tele-Kit and the film loop:

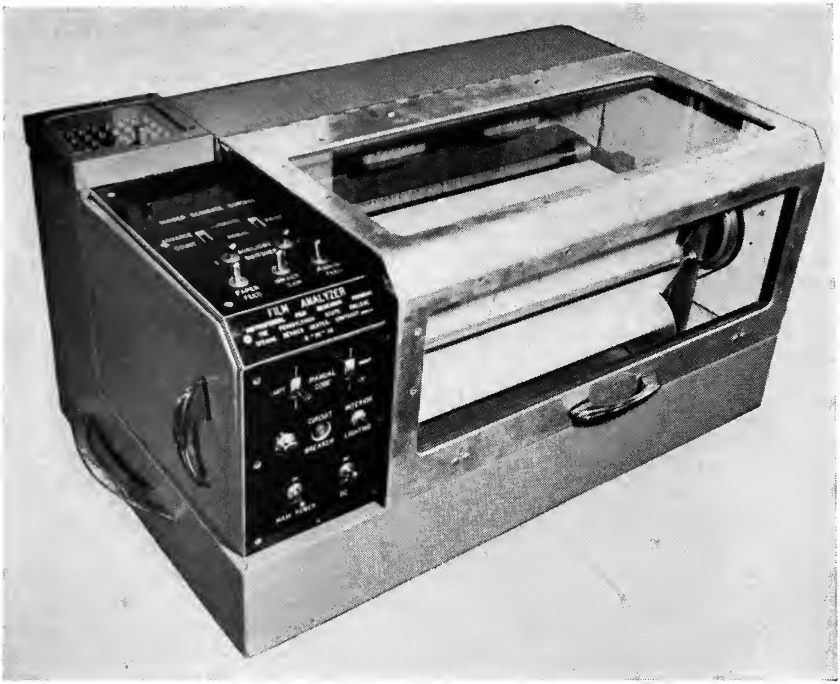

Fig. 2. Film Analyzer Recorder for continuous or intermittent recording of audience responses

1. The effects on learning of various screen-viewing distances and angles. The distances studied ranged from 4 to 24 screen widths, and the angles of viewing the screen ranged from 0° to 60°. The screen size was 12 in. × 18 in.

2. The effects of ambient illumination on learning from a film projected on the "daylight" rear-projection screen. Tests were made under normal room-lighting conditions and in a darkened room.

3. The effects of repeated viewing of a film loop.

4. The relative effectiveness of films having "slow" and "fast" rates of development.

5. The effects of having the trainees practice an assembly task while viewing the film loop.

The task taught by the film was the assembly of the breech block of the 40mm antiaircraft gun. The effects of the film variable or the methods of presentation variables were measured by testing the *actual performance* of the subjects in assembling the breech block immediately after the film showings. About 2000 Navy trainees were used as test subjects.

Preliminary analyses of data show the following results:

1. Viewing conditions. The optimum area for viewing the daylight projection screen lies within a total angle of 60° (30° on each side of the projector axis). This area extends out to a distance of 16 screen widths from the screen (24 ft for the 18-in. screen). Of the men seeing the film from within this area, approximately 75% succeeded in assembling the breech block. Thirty to forty individuals could be seated in this area.

An area of reduced learning effectiveness in which approximately 50% of the

Fig. 3. Instructor's Console of classroom communicator (Veeder-Root Bank of Individuals' Score Summators to right).

men succeeded in learning the task extends around the optimum area described above to a maximum total angle of 100° for daylight viewing and 120° for viewing in the dark. This area of reduced learning extends out to a maximum viewing distance of 24 screen widths along the central projection axis.

2. *Repetition.* Preliminary results of these tests for the repetition variable are as follows: repetition of the film by the film-loop method aided greatly in teaching trainees to assemble the breech block. Two showings were better than one showing, and three showings were significantly better than two, i.e., with repetition more and more men were able to assemble the breech block. It may be assumed that more repetitions would: (1) teach more of the trainees to reach the minimum performance requirements, and (2) improve the assembly skills of trainees beyond the minimum performance requirements. It may be assumed also that a level of diminishing returns of repetition relative to learning would be reached. Training requirements should determine the number of repetitions used.

These tests provide evidence for the soundness of the "repetitive impact training" method and the usefulness of equipment which makes this method relatively easy to apply. By repeated showings of *well-prepared* short units of training films, predetermined training standards can be achieved.

3. Rate of development. A film which was produced with a *slow, deliberate rate of development,* i.e., the showing of an action or sequence of actions with more screen time than is normally used, was much superior to a film with a fast rate of development. Results show that repetition amplifies this advantage and that the disadvantages of rapid, heavily packed or concentrated films cannot be entirely compensated for by repeated showings.

4. Participation. Practice by the trainees of the performance at the same time as it is being shown on the screen aids learning of the skill when used with the *slow-development* film, and reduces learning when used with the fast-development film. It can be generalized from these and other findings[6,7] that in order for concurrent *practice* of a skill being taught by a film to be effective the film must have a sufficiently slow rate of development or allow time between sequences in order to provide favorable conditions for practice or participation.

These field tests of the actual effectiveness of the Tele-Kit daylight rear projection equipment and the T.A. Repetitive Loop magazine demonstrate the kinds of functional testing that can be done with many other kinds of film, radio and television equipment. Such field tests can be used to establish the "operational characteristics" of equipment in terms of what this equipment can actually be expected to do to people, and not in terms of opinions about what the equipment might do when people are involved. For example, there is a general standard that the maximum screen-viewing distance should be limited to six times the screen width. Field tests in terms of effects on learning a skill show that for the film and projector used the effective viewing distance extends to 16 screen widths from the screen but that beyond this distance there is a substantial decline in the subjects' learning. These findings have important implications for television viewing.

Film Variables Positively Related to Efficacy of Instruction in Performance Skills

Four major projects of the Instructional Film Research Program have isolated eight variables that aid learning. In other words, films with the following eight characteristics are likely to be more effective in teaching performance skills than films which lack these characteristics:

1. Medium verbalization. Tests have shown that the optimum number of words in the commentary should range between 100 and 130 words per minute of film.[8] Fewer rather than more words are probably desirable. When complex pictorial material is shown, or when it is necessary to use new terms and words, repetition of these new concepts should be employed.

2. Audience participation. Practice of the skills at the same time as the film is being shown aids learning greatly if favorable conditions for practice are provided.[7] These can be achieved by producing films with slow rates of development so that the action on the screen can be followed *and* the practice carried out without loss of attention to either. Or, short sequences of films may be shown, followed by opportunities for practice, repetition of the same sequences, or the presentation of a new element of the skill to be learned. Portable projectors, daylight screens and television tubes make it possible to present audio-visual instruction to trainees in actual work situations, e.g., on assembly lines. Thus skills can be taught to trainees in situations where they can learn with expert guidance from the film as they practice. When these methods are applied great economies may be made by reducing the amount of trial and error in training, by savings in man hours of both trainees and instructors, and by increasing the *amount of transfer of learning* from the training situation to the actual work situation.

3. Slow rate of development. It has been found to be advantageous to use what might be called a slow rate of develop-

Fig. 4. Communications Test Room showing: Instructor's Console; Film Analyzer; Veeder-Root Bank for summing scores; correct-answer, signal-light panel (on wall); and response stations (on desks).

ment of the subject being presented.[8] This requirement is especially important in elementary introductory training. Clearly, optimum *rates of development* or rates of pacing a film will vary depending on the complexity of the skills being taught, the abilities and previous experience of the trainees, and other factors such as the conditions under which training is being done. It is impossible, therefore, to state a simple rule of thumb. Pacing or development rate interacts with repetition. Repetition may, in part, compensate for the inadequacies of films which "move" too fast. It would seem on the basis of inspection and testing of large numbers of training films that those currently being produced are more often *too fast* in development rather than *too slow*. The abilities of trainees to perceive and learn from a film are generally overestimated by those of us who produce films.

4. Repetition. Repetition has been accepted both in theory and practice as a necessary condition for learning. Sudden learning ("insight") without trials, errors and successes is an exceptional occurrence. The factor of repetition has been accepted and used not only in educational procedures, but is recognized and applied in journalism, advertising and the arts.

The results, therefore, of gains in learning or acquisition of a skill as a consequence of the repetition of film presentations were to be expected.[8] The employment of *repetition* in films for teaching skills can now be recommended with confidence.

There are, to be sure, many unanswered questions: How can the variable of repetition be employed most effectively? How many repetitions are desirable for a particular training job, with a specific group of trainees, in order to achieve a given level of training? How is repetition to be used and yet monotony and lack of interest avoided? How can introductory and summarizing sequences be used to repeat and reinforce instruction? How can repetition be *varied* so that more *generalized* training rather than very *specific* training will be the result? Some of these and other questions must be answered for specific kinds of training; general rules have limited use. This does not negate the proposition that repetition increases the effectiveness of a training film, whether simple repetition of the film as a whole or *internal repetition with variation* is used. It is surprising in this connection that more use has not been made of this simple principle of repetition by producers and users of training films.

5. *Showing errors to be avoided.* Is it desirable to show errors of performance in training films? The results of Jaspen's experiments[8] indicate that errors when shown aid learning of the required performance provided the error or wrong way is clearly described as an error to be avoided and differentiated from the correct method. The trainees must be taught — shown and told — what the errors are and how to avoid making them. It would appear that "negative training," i.e., trainees performing incorrectly rather than correctly as a result of seeing the errors, is a consequence of incomplete training in the discrimination of errors. It might be mentioned here that good coaching usually involves directing the learner's attention to his mistakes. *The simple rule is to show clearly errors to be avoided in a performance.*

6. *Camera angle.* Roshal[6] did an experiment on a pair of variables — the 0° versus the 180° camera angle. In other words the training task was photographed from the viewpoint of the performer (0° angle) and from the viewpoint of the observer (180° angle). The film which was photographed from the viewpoint of the performer proved in actual tests to be superior to the film photographed from the viewpoint of the observer. From this and related studies a simple rule can be formulated: In skills-training films wherever possible *show the job exactly as it will be seen by the trainee when he performs it.*

7. *Personalized commentary.* Zuckerman[9] has studied some of the characteristics of commentaries in training films. He found that the direct personalized form of address proved to be better than several other forms of address. In other words, addressing trainees as "you" and otherwise personalizing the instructional commentary had advantages. In addition, the timing of the commentary to the visuals may have an important influence on learning. In teaching a complex skill, alerting the learner to the action to appear on the screen by having the commentary slightly lead the picture was found to be helpful.

8. *Motion.* Results of experiments tend to confirm the widespread belief that in teaching skills involving action, motion pictures are superior as instructional materials to successive stills of the action.[6] Where the *crucial* cues to be learned are *action* or movement cues, then a *motion* picture representation is superior to those methods which do not represent the complete action. This raises a basic question: What are appropriate training tasks for motion pictures or television? The suggested answer is that those training tasks which involve crucial and complex action are appropriate to those

media which have capabilities of showing such action.

Variables Related to the Efficacy of Informational Films

1. Idea density. We have approached the problem of the *amount*, *rate* and *difficulty* of materials presented by means of films.[10] This problem arises out of considerations of the following questions: How much information can be presented effectively in a given period of time? How does the level of difficulty affect the learning of this material by given audiences? What treatment of a given body of information most effectively carries the informational content to be communicated? For example, is the story form of organization more or less effective than a straight expository presentation, or is an organization with a prominent outline which is repeated and made very clear by titles more or less effective than a smooth uninterrupted development?

The research on these problems is not yet complete or definitive. However, we have developed a strong conviction that for a single film there is an optimal amount of information for a given audience or trainee population. We are also convinced that many instructional sound films are overloaded with information, i.e., more material is presented than can be effectively learned by the audience.

2. Introductions and summaries. We have made a rational analysis of the functions served by film introduction and summary sequences.[11] Tests have shown that introductions and summaries may either *add* or *detract* from the instructional value of films depending on their adequacy. Poor, sketchy and ambiguous introductions and summaries may reduce the effectiveness of the film. On the other hand, cogent, clear and well-integrated introductions and summaries increase the effectiveness. These parts of a film may be used to provide much needed *repetition*, *review* and *emphasis*. They can also be employed to set learning goals or purposes for trainees, to clarify organization and to emphasize the importance and practicability of the film's contents.

3. Pretests and knowledge of results. We have found that pretesting trainees on the information to be learned increases the amount of the learning.[12] Also, when practical, it is worth while to inform trainees of the results (both errors and correct responses) of their attempts to master the learning tasks presented by means of sound films.[13]

4. Color vs. black-and-white films. We have preliminary findings which suggest that most learning tasks may be presented equally effectively by monochrome or color films.[14] Color films have an advantage when crucial cues for learning depend on color. If the thing to be learned (such as the identification of flowers, kinds of wood or geological specimens) depends heavily on color, then the discriminative learning may best be done from color films. However, it would seem there are subtle and, as yet, unmeasured distractive effects involved in instructional color films.

5. Special effects. Studies suggest that devices used in films solely to gain attention, such as "stop-motion" shots of still objects, pictures of pretty girls, arresting sounds or noises and unusual angles used purely for their striking effect, have little or no influence on improving the learning scores of trainees. Such devices do not seem to justify the effort and expense of including them.[15]

An experiment was recently completed on the effect of opticals on learning from instructional films.[16] Three versions of each of two different informational films were prepared. One version of each film had no opticals (straight cuts all the way through); a second version had fades only between major divisions of the film; and the third version, which was the film as originally produced, had a liberal number of fades, wipes and dissolves used in accordance with the generally accepted "rules" for using these effects. The learning results showed no

significant differences between the versions.

6. *Use of films exclusively.* It has been shown repeatedly[4,6,7,8,17] that good sound films can do an instructional job without the aid of highly trained instructors. Thus, adequate films can release instructors from much instructional routine and give them time for instruction of the kind which cannot be done by films, e.g., personal attention to individuals, or applying instruction to immediate specific situations. Furthermore, film-to-trainee instruction puts responsibility for learning directly on the trainee where it ultimately must rest and reduces the responsibility which the instructor must carry.

7. *Practice in learning from films.* Finally, some of our results strongly suggest that students *learn* to *learn* from films.[18] In other words, practice in learning from films increases the facility with which students acquire information from subsequent films.

PRACTICAL IMPLICATIONS

1. In the production and use of instructional and informational films full cognizance must be taken of the characteristics, abilities and limitations of the people in the audiences who are to be instructed and informed. In order to check whether a film is suitable for the characteristics of the target audience and whether it achieves its objectives, it is believed to be necessary to conduct "proving-ground tests" on the effectiveness of the film with samples of the intended audience.

2. Tests of instructional efficacy or learning need not be delayed until films are completely produced, but they may be conducted at several stages during production and prior to release and distribution.

3. No single film can be entirely suitable for an audience with a wide range of backgrounds and abilities; therefore, multiple versions of films which permit great flexibility of use are desirable to meet the needs of different audience levels.

4. Existing methods of film production and utilization can be greatly improved by applying psychological research methods and results. By using suitable films as the main medium of training, high levels of effective instruction can be achieved.

5. Research on the functional characteristics of sound motion pictures and television, as these interact with audiences, is equal in importance to research on equipment and technical processes. The human engineering approach would seem to be essential for further important advances in the communications industries.

REFERENCES

1. C. R. Carpenter, R. C. Eggleton, F. T. John and J. B. Cannon, "The Classroom Communicator," Technical Report SDC 269-7-14, The Instructional Film Research Program, The Pennsylvania State College, 1950.
2. C. R. Carpenter, R. C. Eggleton, F. T. John and J. B. Cannon, "The Film Analyzer," Technical Report SDC 269-7-15, The Instructional Film Research Program, The Pennsylvania State College, 1950.
3. S. F. Harby, "The development of a procedure for using daylight projection of film loops in teaching skills," report in preparation, The Instructional Film Research Program, The Pennsylvania State College.
4. J. Murnin, W. Hayes and S. F. Harby, "The use of film loops as the exclusive means of teaching motor-skills," report in preparation, The Instructional Film Research Program, The Pennsylvania State College.

5. P. Ash and N. Jaspen, "Optimum utilization characteristics of the rear-projection daylight screen," report in preparation, The Instructional Film Research Program, The Pennsylvania State College.
6. S. Roshal, "Effects of learner representation in film-mediated perceptual-motor learning," Technical Report SDC 269-7-5, The Instructional Film Research Program, The Pennsylvania State College, 1949.
7. N. Jaspen, "The effects on training of experimental film variables, Study II." Technical Report SDC 269-7-11, The Instructional Film Research Program, The Pennsylvania State College, 1950.
8. N. Jaspen, "The effects on training of experimental film variables, Study I," Technical Report SDC 269-7-17, The Instructional Film Research Program, The Pennsylvania State College, 1950.
9. J. V. Zuckerman, "Commentary variations: level of verbalization, personal reference, phase relations in instructional films on perceptual-motor tasks," Technical Report 269-7-4, The Instructional Film Research Program, The Pennsylvania State College, 1949.
10. W. S. Vincent, P. Ash and L. P. Greenhill, "Relationship of length and fact frequency to effectiveness of instructional motion pictures," Technical Report SDC 269-7-7, The Instructional Film Research Program, The Pennsylvania State College, 1949.
11. C. W. Lathrop, Jr., and C. A. Norford, "Contributions of film introductions and film summaries to learning from instructional films," Technical Report SDC 269-7-8, The Instructional Film Research Program, The Pennsylvania State College, 1949.
12. J. Stein, "Motivating effects of pretests on learning," report in preparation, The Instructional Film Research Program, The Pennsylvania State College.
13. R. Hirsch, "Effect of knowledge of results on learning from instructional sound motion pictures," report in preparation, The Instructional Film Research Program, The Pennsylvania State College.
14. A. W. VanderMeer, "Relative effectiveness of color and black and white in instructional films," report in preparation, The Instructional Film Research Program, The Pennsylvania State College.
15. D. M. Neu, "The effect of attention gaining devices on film-mediated learning," Technical Report SDC 269-7-9, The Instructional Film Research Program, The Pennsylvania State College, 1950.
16. J. Mercer, "The influence of optical effects and film literacy on learning from films," report in preparation, The Instructional Film Research Program, The Pennsylvania State College.
17. A. W. VanderMeer, "Relative effectiveness of instruction by: films exclusively, films plus study guides, and standard lecture methods," Technical Report SDC 269-7-13, The Instructional Film Research Program, The Pennsylvania State College, 1950.
18. A. W. VanderMeer, "Effects of film-viewing practice on learning from instructional films," report in publication, The Instructional Film Research Program, The Pennsylvania State College.

Film Production Principles—The Subject of Research

By KEN KENDALL

The considerable number of technical and progress reports issued by the Instructional Film Research Program at The Pennsylvania State College for 1948–50 are reviewed. The results of the research are reported and assessed particularly as to their possible meaning for other production as well as for instructional films.

As THOUGH by an overnight snowfall, the face of the art of communication has been changed. By comparison with what is coming, television is reactionary, a mere extra convenience in a new science. The scope of this revolution has even changed the meaning of the word "engineering." This is the story.

Originally engineering meant the art of managing an engine. Yesterday it came to mean the science of making matter and power useful to man. Today it has come to mean a new science, the science of making man useful to man and machines fitted to man. This is called Human Engineering.

To do anything with man, to use him in any way at all we require a tool. That tool is communication. Human Engineering can only be as effective as the completeness of the mastery of the mechanics of that tool. Thus the engineer's striving toward better communications has now shifted its emphasis. The old objective of higher fidelity is now a by-product of the art. The old purpose was to carry a message — an audio-visual message right up to the point of impact on men's senses. The new purpose today is to have communications go behind the eyes and ears and include the mind, the whole man and his behavior. It is now required of good communication engineering that the message be recollected and used by the recipient.

It is worth while thinking of this in terms of money — of communication costs. The revenue-producing motion picture now has a lusty young competitor. It is the sponsored picture. A documentary, an advertising film, a television program, a teaching or training film — any and all of these may be sponsored and shown without a box-office purpose in mind. There are other purposes.

Yet these two masters, the box office and the sponsor, require very different production psychologies. This is be-

A contribution, made at the request of the Society, by Ken Kendall, The National Film Board of Canada, John St., Ottawa, Canada.

cause each has a different way of getting back its money.

Box-office returns depend on fleeting entertainment values. Memory of the picture is not too important. In fact, should viewers forget their first experience and see the show again the returns would increase.

Sponsors, however, seek to purchase pictures whose details will be specifically recollected. With a sponsor, the financial justification of a picture depends on this, and on how well the message is recalled, the information used or the suggested course of action followed.

Inevitably, therefore, the engineering evaluation of the system and the planning of film or television production cannot be divorced or isolated steps in a chain of events. The costs of transmission fidelity now share in the balance with the evaluation of the fidelity of human reactions. Like it or not, picture producers, wherever engaged by sponsors, are now working in a branch of human engineering and must follow the engineering approach of understanding and putting to use the findings of scientific research.

Picture producers and scientific researchers are apt to view any work wedlock between themselves with mutual horror. Artists, writers, musicians and producers have long told the world that all science is a shackle, while research groups test everything until it yells for mercy. Again, most researchers try hard to withhold their findings until proof is completely unchallengeable, a point at which it has usually become totally incomprehensible to the layman.

The researchers say, "Research must be complete before it can be divulged." Others argue, "But think! Research is never complete. The whole of human progress stands on imperfect knowledge, or incomplete but continuing research."

Of extreme news value to the motion picture and television field is the fact that one of the human engineering research groups has decided to allow its interim findings to be reported. The sponsorship of this research is a joint one: the United States Departments of the Army and the Navy have a human engineering project conducted under contract by The Pennsylvania State College.

The following summary is digested from reports covering over sixty research projects in various stages of development. These concern the elements of effectiveness in films which alter audience behavior. A defense project, this research sought to measure the amount of learning produced by special films used in the training of thousands of men. As in all valid science, opinions and judgments not based on test results have been meticulously excluded from the findings or, in some cases, stated only tentatively.

Concerning the Research Method

Skip this section if you wish. It concerns the question of the validity of the new findings. Experienced producers have and will take exception to them. They feel that research teams are not "showmen." Are such teams, they ask, qualified to judge? Similar questions may rightly be expected from all who are connected with motion picture and television production.

The heart of this challenge rests squarely on the matter of the opposed purposes of box-office and sponsored motion pictures. The greater part of the producer's "expert opinion" as to the desirable factors in the production of motion pictures has been based either on box-office returns, or on audience entertainment reactions in theaters, or both. All such evaluation tends to measure only the entertainment value at the time of seeing the picture.

But all sponsored pictures are fundamentally informational; therefore the sponsor (unconsciously or otherwise) is buying a package of "learning" which he wishes the audience to accept and retain. Thus the picture industry's

evaluation of entertainment elements is not relevant to efficiency of informational films.

For such reasons, scientific research into the dynamics of learning from films has had to start from scratch. The measured actual behavior changes in individuals exposed to informational films have formed the basis of all the findings. As with all valid science, the expert opinions of those in the art are held to be unreliable until independently confirmed by actual tests.

This does not mean that the experience and judgment of experts have been excluded from this research program. The number and caliber of learned people connected with the project are formidable indeed. A later section of this paper gives a partial list of the advisers, consultants and researchers who are or have been involved in this project.

The project, called "The Instructional Film Research Program," is under the direction of Dr. C. R. Carpenter, Professor of Psychology, The Pennsylvania State College; and Mr. Leslie P. Greenhill is the Program Coordinator. The scope of this work is shown by the following approximate outline of the personnel and physical facilities used to date:

Personnel

Advisers and consultants	19
Researchers and associates	33
Engineering and development staff .	9
Film production staff	5
Joint military advisory body . . .	7
Cooperating university divisions . .	7
Unit audience (instant reaction) . .	40
Other unit audiences, average . .	70
People used in experiments, approx.	50,000

Tools Used

Special daylight projectors.

Combination workrooms with concurrent projection facilities which enable instant putting into practice of film-taught skills.

Special small projection theater.

Complete instructor or researcher public address facilities enabling dual film and personal instruction to take place.

Special repetitive impact machines.

Special "classroom communicator" or computating multichannel audience reaction machine.

Special "film analyzer" polygraph or synchronous and continuous recorder of audience reactions, decisions and judgments.

Commercial "Pressey Teach-Test" device.

Testing facilities enabling films in production to be tried for efficacy on sample audiences.

Separated audio and visual channels, permitting audio teaching impact versus visual teaching impact to be measured separately and together.

Three-dimensional film facilities; use of color film.

Complete production of experimental films in which the various elements influencing learning can be segregated and tested.

78 special experimental films produced by IFRP for this research ranging from 2 to 30 minutes in length to fit the needs of twelve of the projects.

A number of existing films modified to meet the requirements of other projects.

Clerical system to handle individual viewer recollection fidelity over specified time lapses.

Computing machines for statistical evaluation of the research measurements.

Research Trends

Starting with 45 original research projects (see list at the close of this report) the program to date has formulated and undertaken over 60 research projects. They can be classified into four main categories:

1. Research on the governing factors of films which are expected to change the personal attitudes of the viewer. This attitude change includes opinions, values, beliefs and resulting actions which may be found to last in a given person.
2. Research on the governing factors of films which are expected to impart concepts, facts and principles to viewers.
3. Research on the governing factors of films which are expected to impart skills and arts to viewers.
4. Research on the development of research tools for this new branch of human engineering.

This outline of the Instructional Film Research Program should be appraised against its purpose. Sponsored by the U.S. Department of Defense through the Human Engineering Branch of the USN Special Devices Center, this project has been a specific inquiry into the factors controlling "rapid mass learning." The results have disclosed exact information about the processes (production concepts) which effectively influence human behavior through film or television. Here are the findings:

Film and Video Production Principles Revised by Research Results

Like radio and the press, film and television are transmission devices only. The media of communication are the symbols used, be they words or pictures. Loose thinking has confused this matter so much that so-called research has been directed to establishing which transmission device, radio, television, film, etc., possesses the greatest audience influence. Thus the question of *fidelity of transmission* has been confused with *fidelity of learning* to produce dense clouds of meaningless statistics and much frustration in production craftsmen. Certain definitions in regard to communication symbols have been established and they can be briefly reviewed to advantage here. (*For brevity, the word film is extended to include video.*)

Music is a symbolic form. It articulates concepts frequently difficult to express in language or in photographs. It symbolizes moods and feelings, emotions and tensions. The fact that we cannot always name the mood, emotion or tension conveyed by music is in itself evidence of the symbolic character of music, and of its ability to communicate meanings which are not verbal.

Language on the other hand is a symbolic vehicle of thought and of reason. It is an instrument of naming and conceiving objects and of combining and manipulating concepts and propositions. Language is also the vehicle by which higher intellectual processes are carried on.

Photographs are direct symbols of an elementary or literal type acting as a record of a visual experience.

Motion pictures combine all three of these symbolic forms. It is from the use and integration of these symbolic forms and from their richness in cues to concepts *already formulated by the viewer* that motion pictures derive their enormous potential power to influence human behavior. Thus, while all communications are made by means of symbols, motion pictures are, perhaps, most complicated in this regard.

This complexity of symbolic medium, when considered in film production, gives rise to the following rule. The photographer or producer must actively exclude the mere "literal record" aspect of his science. Each picture must concentrate on communicating its *meaning-evoking content*. This means that every effective shot or picture must have a specific symbolic meaning. This inner meaning which is "seen" by the script writer or photographer must also overlap the specific experience history of the

intended viewer. No significant or lasting recollection is created unless these two considerations have governed the film's production. And of these two, the question of the overlap of the real experiences of the viewer is most frequently apt to be neglected. The point most often forgotten is that what is obvious to the expert or film producer may be anything but clear to the viewer.

Learning Accelerators Found Effective for Films

Factors Related to the Effectiveness of Films for Teaching Performance Skills

So far, 13 factors involved in film production concepts for teaching skills have been the subject of research. They were tested to find which of them positively improved the learning which results from seeing a film that is intended to teach the audience *how to do* something. The factors which have been tested are as follows:

1. Level of verbalization.
2. Explanation of "how it works."
3. The use of technical or specialist terms.
4. Audience participation.
5. Condensed or succinct treatment of the subject.
6. Rate of development of subject matter.
7. The showing of errors to be avoided.
8. The effect of several showings to a viewer.
9. The effect of different camera angles.
10. Effect on learning of motion versus still pictures.
11. Showing the hands of the operator in a film demonstration of a skill being performed.
12. Effect of personal reference in the commentary.
13. Effect of various time relations between verbal instructions and picture.

Of these thirteen factors which are called "variables" by the researchers, those which follow proved to have a positive and most significant influence on the effectiveness of films designed to teach new skills.

1. *Verbal level.* The amount of commentary used to describe the action affects the performance of the viewer. The amount, as measured, rises in efficiency slowly up to 100 words per minute of film and falls as gradually beyond that level. Effectiveness is down by 25% at 40 and at 140 words per minute of film.

4. *Participation.* Audience participation or practice proved to be most effective as a utilization device under suitable conditions. The rate at which the commentary and picture presentation is developed controls this element. Rapid development plus participation acted *against* learning and retention. Slow development which allowed time for the viewers to watch the screen and practice the skill helped learning considerably. An alternative to the slow rate of development is the use of a medium rate of development with opportunities to practice *between* film showings. It was noted that most instructional films used verbal and visual development rates common to theatrical films. These rapid rates were found to be the least effective in promoting viewer recall and performance.

6. *Rate of development.* A slow rate of development is a most important factor in making a film effective. New information in films should be covered pictorially at a speed which is appropriate to the abilities of the viewer. The customary practice of present production is far too fast a rate of development.

7. *The showing of errors.* The showing of common errors or faulty methods to be avoided increases the instructional value of a film. The "right and wrong way" is a most potent film device pro-

vided errors are made explicit and clearly shown as errors.

8. *Effect of multiple showings.* Repetition of the film demonstration materially aids its impact on the viewer. It is recommended that the film itself incorporate a repetition of basic sequences, perhaps with slight variations. (A suitable film, using slow development, inbuilt repetition, and right versus wrong methods was found to be effective in teaching 98% of Navy trainees how to do a gun assembly task. A single showing and *no other instruction* was used.)

9. *Camera angles.* On the basis of the tests, it has been shown that learning of a new performance improves as the film visualization approaches the representation of the viewer himself performing the act. Thus a training film is most effective when a zero degree camera angle is used. The usual "position of an observer" or 180° camera angle was shown to be less satisfactory.

10. *Motion versus still views.* The communication and teaching of action becomes effectively transmitted when the film shows all the *movements* involved in the doing of the new task. A series of static shots which show various steps in the action has been found relatively less effective in the teaching process.

12. *Personal references in commentary.* The use of strong directive statements in teaching-type films is, in general, likely to promote greater learning than the commonly used impersonal type of commentary. Example, "do this" (imperative) or "you do this," etc. This finding is slanted toward military training objectives.

13. *Phase or time relationship of audio to visual.* The use of commentary which is in advance of the picture and alerts the viewer to forthcoming visual elements of importance may be desirable. The order of "lead" found most contributory to learning in a specific experiment amounted to a few seconds.

Of the measurements on the other factors in the list of thirteen, the following were found to be inconsistent or negative:

2. *"How it works" film explanations.* This variable showed results which were very inconsistent. Research is continuing.

3. *Use of technical terms.* The introduction of new names or technical terms was found to impede the learning-and-recall aspects of skills or performance-type instruction films where performance was the measure of learning.

5. *Succinct treatment of subject.* Condensed or succinct treatment of the subject was found to give exceedingly ineffective results. While educators have been aware of this danger, many film producers and technical advisers seem to consider compact productions to be satisfactory. Perhaps cost controls the matter. The term "succinct treatment" is used to refer to a production practice using a fast rate of development, minimal use of repetitions, and generally presenting only the *bare essentials* of the subject to be remembered. While this produces a complete minimum film presentation it was found to be 600% *less* effective than the better experimental teaching films.

11. *Showing hands of the operator performing task.* In the one case where a comparison was made between showing the hands of the operator and not showing them (moving objects by stop motion) results were inconclusive.

Factors Found Directly Related to the Effectiveness of Informational Films

The evidence indicates that films designed to impart *information* effectively parallel, to a large extent, the factors needed for skills instruction.

Slow rate of development and the use of built-in repetition are important contributors to effectiveness.

It has been found that film introductions and summaries may be designed to boost considerably the information retained by the viewer. A poor introductory sequence may mislead the viewers and impair learning.

People will retain more of the information shown when they are intentionally made aware of the amount that they have learned from the film. Such a "knowledge of results" may be made a part of the film. Commentary and flashback in support of a "how much do you remember" recapitulation may imply or lead to self-evaluation results. For teaching functions students learn far more when they are specifically kept informed of their progress.

Color films were found of help only when the color was of crucial importance in the imparting of a specific concept or "crucial cues" in the film.

It has been well demonstrated that information can be taught exclusively by means of films. Groups of viewers having no previous knowledge of the subject, who were supervised by unskilled instructors, learned as much from a series of films as equivalent groups who were trained by expert instructors. (Industry and military sponsors please note.)

Instructional films, if they are to be effective, must match the viewer's background experience and abilities in both an auditory and a visual sense. This indicates:

1. Several versions or treatments adapted to different audience levels;
2. the adoption of "production-stage" showings using sample audiences who are later subjected to recollection tests and other reactions to the film in preliminary form.

Factors Found of Interest in Attitude-Changing Films

So far, the research evidence suggests that film concepts influencing human behavior are most likely to be perceived and adopted if they do not conflict with prior opinions and belief systems of the viewers.

The established attitudes of viewers toward a film's main character and theme are matters of importance to the film's effectiveness in modifying attitudes. From a production point of view, the effectiveness of a film designed to change audience attitudes will depend on the selection of a main character who is suitable for "hero-worship" or "identification mechanisms" set up in the intended audience. Films which exclude the identification mechanism as a persuasive factor have not been proven capable of effectively altering human attitudes or behavior.

Functional Factors of Importance to Effective Learning From Films

A preliminary evaluation of the influence of functional factors on learning was measured by scoring Navy personnel after film instruction. About 2,000 men were used for these tests.

1. Viewing angle and screen distance. The optimum viewing area for a small "daylight" rear projection screen was established as about the same for both daylight and dark viewing conditions within an angle 60° wide. A negligible decrease in learning was found at viewing distances up to 16 screen widths from the screen (24 ft for an 18-in. screen). Of the men in the tests, 75% learned successfully in these positions and at these distances.

An area of reduced learning effectiveness extends around the optimum area to a maximum total angle of 100° for daylight viewing and 120° for viewing in the dark. The maximum viewing distance was 24 screen widths. Within this area 50% of the men learned successfully.

These results have important implications for film and television. The present standard of six times the screen width as the maximum satisfactory view-

ing distance might be revised for informational film theaters, etc.

2. *Repetitive showings.* The repetition of film showings added greatly to learning. Three showings resulted in significantly more men mastering an assembly task than did two showings.

3. *Consecutive versus spaced film showings.* The measurements indicated that consecutive presentation of several films was as effective in ensuring two-week retention of the film information as showings of the same films spaced over several days. The establishment of the efficiency of hour-long showings is of importance to military training applications.

Music in Informational Films

So far experimental evidence in this connection is not conclusive. The following discussion is suggested by the traditional psychological principles of learning, without the supporting evidence of experimental tests.

The researchers point out that the kind of music normally attached to informational films will certainly not operate to accentuate learning. Research has indicated that the mere presence of music may operate in many films to distract and divide attention, or to give the entertainment "set" for viewers. The following relationships suggest useful preliminary trends of thought to be confirmed by future experimentation.

Attitude and opinion molders. Music which is regarded highly by the audience might be used to set up favorable attitudes toward the audio-visual material in the film. The same device could operate in reverse and help form unfavorable attitudes.

Memory reinforcing. The strengthening of new learning by association of the familiar with the unfamiliar may be assisted by the use of familiar music as a framework to aid recall. The repetition of music with a given visual and its variations might be a desirable memory link.

Concept-forming aids. Music might be used as a clue suggesting association by inference with a new experience not previously related to familiar ones. In the same way, the function of music, used as a clue, might aid in pointing toward a problem's solution.

Emotional drives for learning. Music might provide an emotional tone or excitement to the learning experience. Correctly conceived informational films are *designed to leave unanswered questions* in the mind of the viewer toward the solution of which he must actively participate. Music might be used to provide a kind of reward, in that the viewer would feel pride in recognizing correctly the association intended by the music.

Music as a "pointer." Music might be used to direct attention to a particular occurrence in the visual stream or in the sound track. It might provide a source of direction for attention by overcoming previous distractions. Contrasting tone color might be used to sustain attention for long periods and prevent day dreaming.

Interpretation of Research Findings

Some Values of Film in Education, Instruction or Informational Roles

"Do films tend to be of significant value if used for education, training or information?"

1. Films have been found to be equivalent to a good instructor in teaching specific subjects. A longer retention of new information has been found in some cases than was achieved through other methods of instruction.

Discussion. The origin of this research was a postulation of a shortage of competent instructors in the event of a national emergency. The study was undertaken to determine to what extent instructional

films could carry the entire teaching burden using supervisors only.

As an example of the procedure by which this type of research was conducted the case is cited of three comparable groups of 9th grade high school students who were taught a four-unit course in general science over a period of a full semester. *The first group* was taught exclusively through a series of 44 films. *The second group* was taught through the medium of the same films. They also studied before and after each film from specially prepared short study guides. *The third group* was taught by competent teachers using a standard textbook and the customary classroom teaching techniques. No films were used.

The students were given objective tests immediately at the end of each unit of training. Three months after the end of the course a retention test covering all four units was given. They were also tested both before and after the experiment with a standardized test of general science knowledge.

Test Results. Analysis of the test results from the three groups revealed that the three methods were of almost equal effectiveness. The immediate recall tests gave slightly better scores in favor of the films plus study guides group over the classroom-taught group; the films only group was slightly inferior to both of these. The delayed recall tests indicated slightly better performance for the two film groups over the classroom-taught group. Of the two film methods the one using films plus study guides was slightly more effective.

Conclusions. The results of this study suggest that subject matter such as high school general science may be taught by films *alone* as effectively as by a good teacher using the usual repertoire of classroom techniques and demonstration materials. Films introduced and supplemented by brief study guides are better still. It is worth noting that the films selected for these teaching tests were produced without the benefit of the current research into the dynamics of learning through the medium of films. Nor did they make up a systematic series which thoroughly covered the subject matter. Correctly produced films should be able to provide a more than adequate solution for a shortage of competent instructors.

2. People can learn more in less time and retain longer the information derived from films made on these principles.

This has been demonstrated repeatedly when films have been tested against comparable reading materials or lecture presentations. The films required less instructional time. They imparted far more factual learning in the same time. Films in combination with other instructional materials are perhaps better than either alone. This holds for both the immediate and delayed measurements of the learning effects. Audiences have been found to remember more from a film after serveral weeks than after a few days or a few hours. These findings held true even when the films used in the tests did not conform completely to the principles disclosed in the current research.

3. Informational films have been designed to stimulate other learning activities.

When films incorporate established principles of learning they stimulate in viewer groups adult activities such as group discussions, teamwork and the like. Individual viewers have been induced to engage in voluntary reading. Motivation or desire to undertake the development of new skills was induced and followed by effective action.

4. Films have been found to facilitate thinking and to aid in problem solving.

Evaluation of the evidence of film research clearly indicates that the contribution of films as a communication medium is to give greater comprehension and understanding rather than to develop specific detailed recollection. Research studies have demonstrated that people taught by film were better able to apply their learning than people who had other forms of instruction.

5. In short, films can be specifically produced to influence viewer behavior in the long-term sense.

Thus through carefully produced films human beings can effectively acquire factual knowledge, the development of new skills, the formation of new attitudes, motivations and opinions. Films may be expected to effect other educational objectives such as appreciation, orientation, etc.

Evaluation and Summary of Experimental Research Have Suggested Principles Which Govern the Dynamics of Film Influence on Behavior

For convenience, each principle is stated and discussed and some practical implications for film production or utilization are suggested.

The overriding concept in the knowledge of the dynamics of film influence is that the meaning of a motion picture always differs among the people who see the film. What is perceived in a given film will differ with each viewer and will condition the meaning of the film to him.

In order to conform to the dynamics of learning, a film must contain familiar elements or backgrounds, and not too much that is completely new or unfamiliar such as interpretations that are not easily recognized. Yet there must be new information or there will be little learning. At the same time, understanding will be blocked should the information be too new or too difficult. To complicate matters, adult audiences demand or expect material which has the appearance of novelty. Otherwise they feel that their learning ability has been underestimated. Therefore a good training film must appear to challenge the viewer's learning ability. Thus it is essential to understand that while a motion picture does not vary objectively from one showing to another or from one group to another, there will be a variation in its meaning for different individuals. This will depend on the interaction between the psychological characteristics of the viewer, the social circumstances surrounding the audience and the content and treatment of the film. Any effective informational film will owe its validity to the matching of these variables.

First Principle—Films possess their greatest influence when their content has been designed to reinforce and extend the previous knowledge, attitudes or motivations of the viewer.

Discussion. A film will not substantially influence the behavior of a person unless that person can respond to the film in terms of what he already knows—or what he can do—or how he feels—or what he wants. The film can be designed to help change his attitudes and opinions, his knowledge and his skills, provided that it extends or reinforces those elements which he already possesses.

The effects of any motion picture depend on the reinforcing of the viewer's experiences which preceded, follow or are coincident with the actual film showing. Tests have shown that the influence of any one film is limited while the influence of several films is *cumulative* in the dynamics of learning.

Application. The sponsor's money will be wasted if the film is not carefully adapted to the viewer's knowledge-level, or if the film content is allowed to run counter to existing attitudes or motivations of the viewer.

From the sponsor's point of view, whether an influencing film is expected to extend and reinforce, or to reorganize and redirect the present behavior of the intended audience, a given film is ineffective unless it is *planned*, *produced*, *distributed* and *used* as one of a series of related and cumulative experiences operating in a common direction and all designed for the same specific viewers in the audience.

When it is the purpose of the sponsor to redirect behavior patterns and to reorient the motivations of an audience such as a group of Navy trainees, it may be necessary to reinforce the film with complementary impacts through other nonfilm avenues of instruction.

A second principle is that the behavior-influencing impact of film is usually specific and not general.

Discussion. The principle that films have a specific effect holds for all informational objectives. The cumulative effect of related films shown over a period of time and/or reinforced by other means of instruction may be general. Even here, however, this general influence is limited to the area of the instructional content of the films.

Application. From the production point of view, the sponsor has to be brought to the realization that instructional or informational films must be designed to achieve very specific objectives. A statement of film objectives in general terms is of little value to either a sponsoring or a producing agency.

Failure to define the film objectives specifically at the planning stage of production is a handicap which makes it highly improbable that the film will be effective in influencing behavior or otherwise creating conditions for viewer recollection. (Throughout this digest that aspect of viewer recollection which relates to the entertainment value of the film is excluded as being irrelevant to educational objectives.)

The third principle is that required film influence increases directly as the content of the film matches the specific audience response required by the sponsors.

Discussion. The subject of the film and the way that subject matter is treated is instrumental always and only to a specific end product of audience response. This means that the behavior pattern that the film is intended to produce must be directly related to the content and treatment of the film.

Application. It is necessary for the film sponsor to spell out the instructional or informational objectives in terms of the *specific behavior* the film is intended to influence. This means sponsors must indicate what or how the viewers are expected to know, think, feel or do as a result of seeing the films they buy.

When the film purpose is established in this specific way, production time, facilities and expense can be materially saved by the omission of content and treatment irrelevant to the specific behavior the film is intended to produce.

The effectiveness of a given film may be increased by audience participation relevant to the informational objectives.

The fourth principle is that variations in the prejudices or predispositions of the audience influence the reactions to a specific motion picture.

Discussion. Some elements of these variations depend upon audience literacy, abstract intelligence, formal education, age, sex, or previous experience in the subject. Differences in heredity and social experience mean equivalent differences in reaction to the film, and these differences seem to increase with maturity.

It has been found that intelligence and formal education are directly related. Viewers of above-average intelligence and education learn more from films than those with average or below-average education.

Below-average education viewers learn

very much *better* from films than from verbal instruction.

The retention of film content has been found to decline with age after a certain point.

Sex differences in response occur when the values or occupations shown in the film are sex-typed.

A film has bias but the bias of the audience also counts. The recollection tendency of the viewer depends on his acceptance, rejection or indifference to the bias of the film.

Tests show that the more an audience knows about a given subject the more it will learn from a film on that subject.

One interesting point which the research has brought to light concerns the influence of many films on the same viewer. The first principle showed that a series of related film experiences all operating in the same direction is cumulative. However, the fourth principle exemplifies the fact that the more films of any type which are seen the more the viewer tends to learn from any single film. People learn to learn from films.

Application. The research has disclosed that while the behavior-influencing impact of a film may be in the direction of the bias of the film the force of this impact will vary among the viewers depending upon their respective histories. To a surprising extent there will be instances of behavior influences the reverse of those intended by the film. An *effective* film will not have this result because its *production is planned and it is produced and used* according to an integrated psychology using the dynamics of learning.

Effective informational film planning, production and use depend on information as to the age, attitude, intelligence, education and social outlook of the specific audience for which the film is designed. These must be spelled out by the sponsoring agencies.

If informational films are designed for a general audience they should be sighted slightly below the average of intelligence and education rather than above it. This practice has been found to be the most effective treatment. Viewer learning was measured and it dropped rapidly when the "sighting" of the film was slightly above the audience educational level.

If a sponsor intends to influence audiences of widely different mental levels it has been found almost essential to have several versions of the film made for several IQ's.

The fifth principle is in two parts:

1. Both audio and visual elements of films are effective channels of communication. Neither channel is consistently better than the other. Each channel is uniquely capable of conveying certain types of information and the two should be properly integrated.

2. The overall influence of the motion picture is thought to be primarily in the picture and secondarily in the accompanying language. It is relatively unaffected by the slickness of production.

Discussion. The measurements indicated that the presentation of a film as a whole or the presentation of either the audio or the visual channel alone resulted in significant learning.

Both channels together were consistently better than either one alone. This "both" factor has been identified. It is established that some items are learned jointly from the audio and visual elements working together. Evidence also exists to show that items are often taught via both audio and visual channels in an overlapping sense, in which case the cumulative value of the "both" factor is reduced.

Color film has *not* been demonstrated as generally superior in information and instruction to black-and-white film.

Attention-gaining devices, either visual or auditory, have *not* been found to add significantly to learning in an otherwise correctly made informational film.

Optical effects and other film tricks have *not* been found to contribute sig-

nificantly to learning from informational films.

Too much or too little talking in words per minute of film has been found to detract from the teaching effectiveness of a film. The optimum word rate is about 100 words for each minute of film.

Application. No film should be planned that does not lend itself to fluent picture conception and specification.

With sound films equal care should be given to the verbal conception and specifications.

Since both channels together are more effective than either alone the objective is to achieve the best possible *integration* of the visual and audio elements of film. The "both" factor of this integration should be controlled. That is, single concepts should be imparted through the audio and visual channels working together.

The various attention-getting devices and other luxuries of entertainment films are found to be *not* significant in the dynamics of instruction by films and are seldom noticed by the audience.

The findings of these studies appear to be relevant to television.

The sixth principle is that the recollection of a film depends on the viewer's feeling that the action is significant and is in a familiar background.

Discussion. Not everything shown or said in a motion picture is seen or heard by the viewer. His response to film is selective not photographic. Scenes and sequences are best recalled when the pictorial background is familiar to the viewer and when the action has specific meaning to him. What counts is not the action but the importance of the action, not the close-up but the significance of the objects in the close-up, not the manner of performing the task but the meaning of the task to the viewer.

Application. The special forms of visual and audio film treatment such as cartoon, live photography, dramatic or straight treatments are not instructionally or informationally important in themselves.

Whatever form of treatment is used in the film, it is essential that important scenes and interpretations be *made to appear* important to the viewer.

Light humor helps, but slapstick hurts instruction and information.

The seventh principle is that an intense, efficient and predictable response occurs when the picture content has a personal relationship to the viewer.

Discussion. It has been found that the influence of the film on the attitude and factual learning of the viewer is related to the prestige attached by the viewer to the role of the principal character.

The position of the viewer, or zero camera angle, should be used instead of the 180° angle which is so frequently used in informational films. It has been found that the subjective approach is important to long-term recollection.

Showing the errors likely to be made when carrying out the task improves the instructional value of a training film.

Direct instructions or direct address to the viewer should be used. The third-person, passive voice has been found to retard learning.

Application. The content of an informational film is always better if it is treated in the way members of the audience would see the subject if they were dealing with it in real life.

The production treatment should be designed so that the viewer can see himself in the picture and identify himself with the principal characters.

The appropriateness of a film to an intended audience should determine its distribution. Its photographic excellence or its appeal to an expert should be secondary considerations.

The eighth principle is that the rate of development of a film's message must be slow rather than fast.

Discussion. Where recollection, learning or information rather than entertainment is involved, a slow, rather than a rapid rate of development is important. Rapid development of the presentation of a film subject reduces the amount of learning very materially.

Application. For maximum recollection it is necessary to gear the rate of development of the subject and the information of the film to the rate of learning of the audience. This presupposes that the audience level of intelligence is known.

The rate of learning of the audience is generally slower than the film producer thinks. It is a waste of the sponsor's money to try to cover too much too quickly in any one film.

The ninth principle is that instructional techniques built into the film or applied by an instructor substantially increase learning.

Discussion. The research conclusively shows that the following techniques add to the effectiveness of instructional films:

1. An orienting introduction and a relevant summary of the content of the film are of significant value.
2. An opening announcement of a check-up or quiz on the learning from the film measurably improves the recollection value.
3. Repeated film showings and/or repetition within the film itself, materially improve its recollection value.
4. Audience participation or practice during or following the film showing, "locks in" the teaching.
5. Presenting the viewer with a knowledge of the results of his learning is of great significance.

Application. For rapid mass teaching it is desirable to make films which undertake the total training. They should have instructional techniques and methods built right into them.

Auxiliary instructors can provide motivation, interest and leadership. These are necessary because motivation and morale carry over to the film learning even if the instructor is not present during the film showing.

These leaders or instructors should be trained in the dynamics of learning and its application to rapid teaching by film.

Conclusion

The unusual and commendable action of the Instructional Film Research Program in publishing interim reports on research in progress is planned to continue. These researchers point out that their main responsibility is *to do research* and, therefore, limits must be expected on the amount of report writing.

The most important implication of this work is that existing methods of film production and film utilization can be greatly improved by applying research methods. The conventional research into factors improving communication tools such as radio, motion pictures and television must be extended to become an exact knowledge of audience-influencing factors.

If the scope of communication is to meet the sponsor's requirements, if communication is to be extended behind the eyes and the ears to include effective influencing of viewer behavior, then the human engineering approach is essential for further advances in motion picture production and other branches of communication engineering. The communication industries have high stakes in this emerging field of research and application.

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Dr. William Timmons, Navy Photographic Center

List of Research Reports

Technical Reports

SDC 269-7-2, Music in Motion Pictures: Review of Literature With Implications for Instructional Films (Rapid Mass Learning) May 15, 1949.

SDC 269-7-3, The Relative Effectiveness of Massed Versus Spaced Film Presentation (Rapid Mass Learning) June 30, 1949.

SDC 269-7-4, Commentary Variations: Level of Verbalization, Personal Reference, and Phase Relations in Instructional Films on Perceptual-Motor Tasks (Rapid Mass Learning) Dec. 15, 1949.

SDC 269-7-5, Effects of Learner Representation in Film-Mediated Perceptual-Motor Learning (Rapid Mass Learning) Dec. 15, 1949.

SDC 269-7-6, Learning Theories and Instructional Film Research (Rapid Mass Learning) June 1949.

SDC 269-7-7, Relationship of Length and Fact Frequency to Effectiveness of Instructional Motion Pictures (Rapid Mass Learning) Nov. 1949.

SDC 269-7-8, Contributions of Film Introductions and Film Summaries to Learning From Instructional Films (Rapid Mass Learning) November 1949.

SDC 269-7-9, The Effect of Attention Gaining Devices on Film-Mediated Learning (Rapid Mass Learning) Mar. 1950.

SDC 269-7-10, The Effects of Prestige and Identification Factors on Attitude Restructuring and Learning From Sound Films (Rapid Mass Learning) Mar. 1950.

SDC 269-7-11, Effects on Training of Experimental Film Variables Study II: Verbalization, "How-It-Works," Nomenclature, Audience Participation, and Succinct Treatment (Rapid Mass Learning) Mar. 1950.

SDC 269-7-12, Effect of Repetitive Film Showings on Learning (Rapid Mass Learning) Nov. 1949.

SDC 269-7-13, Relative Effectiveness of Instruction by: Films Exclusively, Films Plus Study Guides, and Standard Lecture Methods (Rapid Mass Learning) July 1950.

SDC 269-7-14, The Classroom Communicator (Rapid Mass Learning) Oct. 1950.

SDC 269-7-15, The Film Analyzer (Rapid Mass Learning) Oct. 1950.

SDC 269-7-16, The Effects of Inserted Questions and Statements on Film Learning (Rapid Mass Learning) Sept. 1950.

SDC 269-7-17, Effects on Training of Experimental Film Variables, Study I: Verbalization, Rate of Development, Nomenclature, Errors, "How-It-Works," Repetition (Rapid Mass Learning) Oct. 1950.

SDC 269-7-18, Comparison of the Audio and Video Elements of Instructional Films (Rapid Mass Learning) Nov. 1950.

SDC 269-7-19, Instructional Film Research 1918–1950 (Rapid Mass Learning) Dec. 1950

Progress Reports

Special Report No. 1, Practical Principles Governing The Production and Utilization of Sound Motion Pictures, SDC Human Engineering Project 20-E-4.

Incidental Report No. 2, Some Aspects of Learning From Films, SDC Human Engineering Project 20-E-4.

Progress Report No. 9, Instructional Film Research Program, Nov. — Dec. 1948, SDC Human Engineering Project 20-E-4.

Progress Report No. 10, Instructional Film Research Program, Jan. — Feb. 28, 1949, SDC Human Engineering Project 20-E-4.

Progress Report No. 11–12, Instructional Film Research Program, Mar. — June 30, 1949, Number, Title, Status and Progress of Research Projects, General Summary of Trends of Results: The Instructional Film Research Program 1947–1949, Summary Report on Project No. 5, SDC Human Engineering Project 20-E-4.

Progress Report No. 13, Instructional Film Research Program, July — Nov. 30, 1949, SDC Human Engineering Project 20-E-4.

Progress Reports No. 14–15–16, Instructional Film Research Program, Dec. 1, 1949 — Mar. 31, 1950, SDC Human Engineering Project 20-E-4.

Audio-Visual Instruction Conference

Report by D. F. LYMAN

An invitation to attend the Winter Conference of the Department of Audio-Visual Instruction (DAVI) of the National Education Association was extended to Boyce Nemec, Executive Secretary of the Society of Motion Picture and Television Engineers, by Don White, Executive Vice-President of the National Audio-Visual Association, Inc. (NAVA), and J. J. McPherson, Executive Secretary of DAVI.

NAVA has been cooperating with DAVI and the American Association of School Administrators in preparing specifications for the design of classrooms and school buildings that will insure effective use of projected audio-visual material. In his invitation, Mr. White stated that two important points require immediate attention: methods of darkening classrooms; and provision in each classroom of the necessary facilities for projection. These include essentials such as conduits, switches and electrical outlets. This information is needed soon for the architects now designing the many school buildings that will be built in the next few years. Later, guidance will be needed on questions such as the optimum size and luminance of the screen, and the amount of illumination in the room during projection. Mr. White invited the SMPTE to cooperate in locating existing technical information and in helping with any research that may be needed. The Winter Conference was held by DAVI at the Hotel Kenmore in Boston on February 6–9, 1952, during which there were several meetings on this point.

Through arrangements made by F. T. Bowditch, Engineering Vice-President of SMPTE, the writer of this review went to the conference and attended the sessions of Action Planning Section 3, Buildings and Equipment.

DAVI Organization

As brought out in the business meeting held on February 8, DAVI is an affiliate of the National Education Association, with Headquarters at 1201 16 St., N.W., Washington 6, D.C. A staff of six people handles the correspondence and other work of the organization. There are now over 1400 members, and the annual operating budget is $32,000 of which $6,000 is from membership dues. DAVI has 15 Action Planning Committees, of which 13 are now national in scope. Many are concerned with general educational problems related to the audio-visual field, but the following are of particular interest to the SMPTE: Section 3, Buildings and Equipment; Section 7, Instructional Materials; Section 8, Production of Audio-Visual Materials by Colleges and Universities; Section 10, Radio and Recordings in Education,

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A report submitted February 15, 1952, by D. F. Lyman, Eastman Kodak Company, Camera Works, 333 State St., Rochester 4, N. Y.

Section 11, Relationships Between Education and the Audio-Visual Industry; Section 12, Research; and Section 15, Television in Education.

As literary outlets, there are available to the organization *DAVI Proceedings* and the magazine *Educational Screen*. One committee is working on a *DAVI Yearbook on the Administration of Audio-Visual Programs* of which the first issue is due in the next year or two. As soon as the tentative specifications on Buildings and Equipment are finished by Section 3, they will be published in temporary form. Then in 1954, it is expected that the first *Yearbook on Buildings and Equipment for Audio-Visual Education* will be ready, with the results of the research now being instigated.

Operation of Conference

At this Winter Conference, there were over 350 registrants from 25 states and Puerto Rico. Their method of operating was different from that of the SMPTE in that prepared papers or lectures were restricted to two evening sessions and the final morning of the conference. There was a get-together luncheon on the first day, much like ours, but here a keynote address was given, after which the main group divided into Action Planning Sections which met in separate rooms for discussions and drafting of recommendations. In this conference most of the 15 groups, which varied in size from 8 or 9 people up to 50 to 60, met three times. There was also one business meeting in which the entire conference participated. One interesting variation took place on the final morning when a reporter summarized the work performed by the various committees at this conference. This was followed by a symposium on "Television's Challenge to Education," in which a chairman and seven speakers took part, after which the conference adjourned.

Buildings and Equipment Section

Section 3, Buildings and Equipment, is of particular interest to the SMPTE Committee on 16mm and 8mm Motion Pictures because of the work done in 1941 along the lines of projection in classrooms,[1] and the efforts, after the war, in which an uncompleted attempt was made to revise and expand the original report. Some of the research problems now confronting DAVI are the same problems that are listed on the SMPTE's agenda for research. The optimum screen luminances for various types of film and various levels of ambient illumination are included in this category.

A previous meeting of Section 3 had been held on November 17, 1951, in New York City.[2] Certain provisional drafts were available from that meeting, and several members had prepared recommendations on certain points for consideration by the group meeting in Boston.

General Architectural Planning

The notes that follow are not intended to give the exact content of the specifications, which are not yet in final form, but merely to indicate the general trend of the discussions. The first discussion dealt with the influence that the architects have on the design of school buildings and how they obtain their final plans. Some make a real effort to survey the needs of the community, while others work from drawings outlining certain requested features. Some school districts have definite ideas of what they want, and it is essential that in such cases the utmost cooperation be obtained from the architects. They stress, however, that they much prefer to work from stated requirements rather than merely to assemble architectural features that have been prescribed by someone else. In this way there is less restriction from a creative point of view.

Ideally, architects should have some training in education. One source of trouble in obtaining audio-visual facili-

ties has been that when costs of proposed buildings are high, features provided for audio-visual instruction are often the first to be scrapped.

In one city, 18 million dollars have been allotted for the rehabilitation of old buildings. There are many local committees working on their separate needs, from the standpoint of the uses to which the buildings are to be put. But fast action must be taken by this Section 3 if its recommendations are to be available in time for this large remodeling project. It was decided, therefore, that screens and other purchased accessories would be kept in the background for the present, and that the committee would concentrate on architectural recommendations for the buildings themselves.

Classrooms

Since there is general agreement that the classroom is the first and most important place to equip for audio-visual activities, certain details were laid down for such rooms. The items covered include the number of electrical outlets, their location, their current-carrying capacity, wall switches for the room lights, conduits for connections to the loudspeaker, acoustical properties of the room, for which standards outlined by the Acoustical Materials Association[3] were specified, ventilation, control of the illumination in the room so that 0.1 ft-c can be obtained during projection, storage of equipment, the size and type of screen, its location with the bottom edge at the eye level of the pupils in each particular room, the method of mounting the screen and dimensions of projection stands. A screen width of one-fifth the distance to the farthest row of seats was preferred to the usual one-sixth. In many ways this work parallels Adrian L. TerLouw's recommendations in the September 1945 *Architectural Record.*

Subjects for Research

The next considerations were of the questions that require research: the size and luminance of the screen with respect to the illumination in the room; the extent of the equipment needed; methods of raising the priority of audio-visual equipment and obtaining community support for it; methods of darkening the room; functions of building coordinators; and ways to persuade those who publish illustrations of "beautiful" classrooms to include audio-visual equipment and materials in their pictures, and to show the method of darkening the room.

A member from California showed a motion picture demonstrating an interlocking type of venetian blind that is engaged in channels. This screen, which has been used in some of their schools, lowers the illumination to about 0.5 ft-c under the outdoor lighting conditions encountered in California.

In this connection, there was some discussion of the possible advantages of windowless classrooms. Some members thought that if windows were omitted entirely, the benefits would be as follows: the pupils could neither see nor hear outside disturbing influences, such as street traffic; darkening of the room would not be a problem; the regular lighting for the classroom could be controlled more precisely; it would be easier to treat the room acoustically; and the acoustics would be constant, whether or not the room was darkened. Not much was said about the arguments against this idea.

In keeping with the precepts of those working in the audio-visual field, the committee made plans for the preparation and circulation of a film strip illustrating good practice in the design of classrooms, and possibly some of the things that should be avoided.

Auditoriums

Specifications for auditoriums were discussed next. Again the acoustical treatment was left to the specifications prepared by the Acoustical Materials Association. One member believed that

architectural conditions for auditoriums are so varied that the committee could not write effective specifications. For example, some architects are now discouraging the construction of projection booths because of the complications and expense involved. It was decided that there should be no reference to a booth, but that the switches, outlets, conduits and other facilities should be specified for a "projection station." Thus the projector could be located in a booth or in some other spot where it would interfere as little as possible with the functioning of the auditorium. Here the screen size was made one-fifth the distance to the rear row of seats, but not greater than 9 ft × 12 ft. Plans were made for connecting the audio-visual equipment to the large public-address system in the auditorium, whenever possible. It was agreed that the auditorium should have no windows, and some believed that the illumination should be even less than the 0.1 ft-c specified for the classroom.

Preview Rooms

It was decided that a statement should be included in the recommendations that audio-visual activities belong in the classroom or in the auditorium, and that no attempt should be made to substitute a central room reserved for audio-visual instruction only. Some members, however, stressed the need for a room where the teachers can preview the material they are going to use in the classroom. Then there must be space for storing equipment and editing films. In some schools there should be office space for the director of audio-visual aids. In many cases these facilities can be provided in one room, and this room should be centrally located and near the library.

Special Reports

Submitted to the committee for guidance at this meeting, a *Preliminary Report of a Study of the Problems of Light Control in the Classrooms of Southern Calilifornia*, was of considerable interest. This was prepared by the Research Committee of the Audio-Visual Education Association of California, Southern Section. It is not complete, but it does cover 567 schools and 8591 classroom units. Only about one-third of the classroom units have satisfactory control of the light for projection. The same ratio applies to 886 classrooms under construction, but of 589 classrooms in the planning stage, only 12% are being equipped for darkening. Of 191 classrooms being remodeled, or in the planning stage for remodeling, only 20% are being so equipped.

This is a serious situation because it looks like retrogression instead of progress. The report points out that large expenditures have been made for audio-visual materials and equipment, yet "Audio-visual directors have been faced with the dilemma of spending money and energy developing audio-visual resources only to have difficulty at the point of application, the classroom, where, in too many cases, no light control exists and children cannot see the fine films and other materials that are available to help them learn."

Some architects are advocating the use of small, bright screens in fairly well-lighted rooms. Illuminations of 10, 15, 50, or even more, foot-candles are mentioned. This information applies particularly to slides. Whether or not the picture is still effective with the low contrast obtained in this way is a factor that should be considered.

Need for Liason

The Society of Motion Picture and Television Engineers can be of assistance to the DAVI committee because of the fund of information in its carefully prepared *Journal*. Some of this is now being furnished directly to Action Planning Section 3 of DAVI. Certain SMPTE committees may find it desirable to cooperate directly with DAVI committees.

The personnel of the DAVI organization have much more direct knowledge of what is transpiring in the educational field than most of our members have, and they know much better what the real needs are. When the DAVI committee starts to write specifications or recommendations for equipment, it will need a great deal of help because of the complexity of the problems involved.

References

1. "Recommended procedure and equipment specifications for educational 16-mm projection," *Jour. SMPE, 37:* 22–75, July 1941.
2. (Report of Section 3 Meeting) *Educational Screen, 31:* 18, Jan. 1952.
3. *Theory and Use of Architectural Acoustic Materials*, Acoustical Materials Association, 59 E. 55 St., New York 22, N.Y.

Television Studio Lighting

Committee Report by RICHARD BLOUNT

The Television Studio Lighting Committee of the SMPTE met in New York City on April 16, 1952, to discuss means of measuring studio lighting. As originally planned, the meeting was attended by numerous lighting directors from the various networks who provided the practical approach to this problem. From the discussion, it became apparent that incident light is measured because simple meters are available, but that brightness would be measured if a meter of similar simplicity and size were available. Since such a device will probably be somewhat more difficult to obtain, the Committee decided to establish desirable characteristics of both types of meters with the thought that an incident meter could be made without any great delay. This would give the studio personnel a standard measuring device which could be used until a convenient brightness meter can be produced.

The following listing of specifications was tentatively agreed to at the meeting, and these are to be given wide publicity among meter manufacturers and users for further suggestions. These proposed specifications are being published here to encourage comment from any interested reader of this report.

Specification for an Incident Light Meter

1. The spectral sensitivity shall conform closely to that of the 5820 image orthicon camera tube.

2. The coverage angle shall closely approach a cosine distribution, i.e., the response shall be maximum perpendicular to the plane of the photocell and shall be 70% of the maximum at $\pm 45°$ from the perpendicular.

3. The meter shall have a single scale and shall respond from 0 to 300 ft-c. The scale shall be logarithmic with 0 to 30 ft-c covering approximately 25% of full scale.

4. The size, and weight and shape shall be such as to be conveniently carried in a suit coat pocket. Rounded edges are desirable since the meter will be hand held in use. A maximum thickness of one inch is desirable.

5. An adjustable-length neck cord is required. The maximum length should allow the meter to rest in a trousers pocket.

6. The meter should withstand reasonably rough handling similar to that experienced by photoelectric exposure meters. A storage case may be provided at the manufacturer's option.

Preliminary Specifications for a Portable Brightness Meter

1. The instrument shall incorporate a photoelectric device for light measurements and shall be dependent upon the human eye for aiming only.

2. The spectral response shall be similar to that of the 5820 image orthicon camera tube.

A report submitted on April 23, 1952, by the Committee's Chairman, Richard Blount, General Electric Co., Nela Park, Cleveland 12, Ohio.

3. The angle of coverage shall be $1^{\circ}{}^{+1^{\circ}}_{-0}$.

4. The instrument shall measure brightness from 70 ft-L max down to 1 ft-L, with 0.1 ft-L as a very desirable minimum. This range may be covered by a number of steps—perhaps in multiples of 10. Switching between steps should be accomplished internally. No separate, external filters or other devices shall be used.

5. A sight or viewfinder which provides an upright image shall be incorporated. It shall enable the operator to quickly and positively identify the area to be measured. Parallax shall be kept to a minimum.

6. The meter shall be designed so that the operator can make a single measurement in less than five seconds, but will allow him to read the actual value at his leisure.

7. The meter shall not require external power and shall be built as a single unit.

8. If battery-operated, it shall be able to operate continuously for at least 10 hours on a single set of batteries.

9. The calibration shall be stable throughout the battery life. A simple external calibration device shall be made available.

10. The meter should not exceed 400 cu in. and the weight shall be no greater than 5 lb.

The Committee appreciates that the brightness meter specifications may be difficult to meet, but in the apparent absence of any meter that meets the needs of television stations, it was decided to state the precise requirements and compromise later if necessary.

Revision of Screen Brightness Standard

THE PROPOSAL of the Screen Brightness Committee to revise Z22.39-1944, Screen Brightness for 35Mm Motion Pictures, is limited solely to the addition of a phrase excluding outdoor theaters.

A careful survey did not indicate a need for changing the brightness level recommended for indoor theaters and the proposed change simply recognizes the problem of outdoor theaters. These theaters, with their large screens, were not originally considered in arriving at the standard for screen brightness, and a large portion of these are unable to meet the standard with presently available equipment; hence the screen brightness standard has been revised to pertain solely to indoor theaters.

Due to the fact that both indoor and outdoor theaters use the same release prints, the Screen Brightness Committee voted to add a note urging the outdoor theaters to use this standard as a goal. The Standards Committee supported this position and authorized preliminary publication for a 90-day period of trial and criticism.

Please send comments to Henry Kogel, Staff Engineer, at Society Headquarters, before August 15, 1952. If no comments are received during the three-month trial period, this revised standard will then be submitted to ASA Sectional Committee PH22 without further vote within the SMPTE and with the recommendation that it be processed as an American Standard.

Proposed American Standard **Screen Brightness for 35mm Motion Pictures**	**PH22.39** Revision of Z22.39 — 1944

Screen Brightness

The brightness at the center of a screen for viewing 35mm motion pictures in indoor theaters shall be 10^{+4}_{-1} foot-Lambert when the projector is running with no film in the gate.

Note: Outdoor theaters have been excluded from the above standard because of their inability to meet it. It is recommended that outdoor theaters approach the indoor standards as closely as possible in view of the fact that the same release prints are generally used for both types of theaters.

NOT APPROVED

Engineering Activities

71st Convention The Engineering Committee meetings at the 71st Convention were in the main well attended and demonstrated a high degree of member participation and interest. The highlights of the meetings are:

Film Dimensions The further decrease in the shrinkage characteristics of 16mm film creates a twofold problem: (1) the width must be decreased to preclude film stickage in the gate; and (2) a decrease in the stated width dimension in the standard might erroneously lead equipment manufacturers to decrease the gate dimension and thereby start a disastrous merry-go-round.

The proposed solution was that the existing standard be revised by placing an asterisk beside the width dimension and indicating below that for low-shrink film the standard is 0.628 ± 0.001. Low-shrink film would then be defined in the Appendix. A letter ballot on this proposal will be sent shortly to the full committee.

Film-Projection Practice The committee first outlined plans for a major increase in activity and then reviewed a previous recommendation that American Standard Z22.58, Projector Aperture Dimensions, was unsuitable for international standardization. It is now felt that although certain features of the standard do require revision, the basic dimensions are valid and valuable both here and abroad and the previous recommendation was therefore reversed.

Laboratory Practice The three active projects were reviewed and a fourth one proposed:

1. The Proposed American Standard Enlargement Ratio for 16mm to 35mm Optical Printing, published in the January *Journal*, is now well on its way toward standardization.

2. Screen Brightness for Laboratory Review Rooms, presently out to letter ballot, is meeting with difficulty primarily because of the conflicting needs of three classes of 16mm print consumers: amateur, television and Navy. This is now to be considered by the Screen Brightness Committee, after which this committee will attempt to draft a compromise proposal.

3. Printer Light Change Cueing of 16mm Negatives, a proposal to eliminate negative notching, has just been sent to the committee. Preliminary comments at the meeting indicated that redrafting may be required.

4. A new project to produce a glossary of chemical terms used in motion picture laboratories was initiated.

High-Speed Photography In addition to the primary discussion on preparations and responsibilities for the symposium at the Fall Convention in Washington, the committee discussed the need for a glossary and agreed upon the initial steps to achieve one.

Screen Brightness The various subcommittees reported on their progress to date and mention was made of the formation of a new subcommittee on illumination practices to make recommendations on uniformity of illumination across the screen. The ICI recommendations on screen brightness were discussed and it was noted that the American Standard falls within the recommended range:

ICI = 7.3–14.6 ft-L
American Standard = 9–14 ft-L

Plans were made to continue the screen brightness survey of outdoor theaters as soon as weather permits.

16mm and 8mm An extensive agenda was considered and a continued high level of activity projected. As a result, the full committee will soon be voting on revisions of six standards in an effort to make them consistent as to emulsion position, edge guiding and titles (Z22.9, .10, .15, .16, .21, .22). A letter ballot is also to be taken on a compromise proposal on PH22.75, "A" and "B" Windings of 16mm Raw Stock which may resolve the existing deadlock on this thorny issue. Reels for a 15-min show (600-ft size) as well as reels over 2000 ft were discussed and assignments given for gathering additional required information.

Sound Of the several items considered, the magnetic sound track proposals were, of course, paramount. These were published in the July 1951 *Journal* for trial and criticism and it was up to the committee to pass on the comments received. After a full and rounded discussion, the committee approved the proposals as published, with minor modifications which in the main are editorial in nature, and officially submitted them to the Standards Committee for further processing as American Standards.

Consideration was briefly given to other magnetic sound track proposals and also to magnetic test films. The nature of the discussion revealed the need for a meeting of the Magnetic Recording Subcommittee which was scheduled for and held the following day. The Subcommittee reached no decisions but proceeded efficiently to outline a major program of work on test film specifications (azimuth and multifrequency) and additional sound track standards.

ISO Delegation A very workmanlike job was done to prepare the group for its role at the forthcoming meeting of ISO TC/36 in New York on June 9 and 10. The delegation discussed point by point the position it would take on the various Agenda items. A copy of the Agenda for the international meeting and the U.S. position is available upon request.—*Henry Kogel*, Staff Engineer.

University Film Producers Association

The University Film Producers Association held its first meeting in the summer of 1947 at the University of Iowa, Iowa City, Iowa. The organization came into being as a result of the evidenced need for university film makers to meet and discuss their mutual problems. The initial session was a one week's conference and workshop. This pattern was so successful that the group still follows it.

At the time of the first meeting, many problems confronted the university film producers, such as personnel, music rights, exchange, distribution, technical practice and laboratory service. Many universities had the same problems. Some had solutions, some did not. It was evident that a clearinghouse was needed for the exchange of information and ideas.

The first meeting included representatives from nine educational institutions and two commercial organizations. Today there are approximately 60 members from educational institutions, as well as representatives from commercial film companies, laboratories, film distributors, and equipment manufacturers.

The purpose of the University Film Producers Association has been very clear since the inception of the organization. "It shall be the purpose of the UFPA to further and develop the potentialities of the photographic and recording arts in improving instruction and communication." Individuals, organizations and educational institutions qualified for membership are encouraged and invited to join the University Film Producers Association. There are at present four classifications of membership: active, associate, institutional and sustaining.

In its half-dozen years of existence the UFPA has grown in accordance with its original plans. It is today an incorporated, nonprofit organization whose members include teachers, professors, film makers, film technicians, film companies, film laboratories, film distributors, equipment manufacturers and dealers, and university motion picture students.

Annually, during the month of August, the Association meets in a city chosen by the members. August of 1952 will find the organization guests of Syracuse University, Syracuse, N.Y. The week-long conference includes a variety of program subjects, such as technical problems of film production, research, film curriculums, distribution, film screenings and films for television. Equipment manufacturers and distributors display and demonstrate new equipment at the meetings. The lectures, demonstrations, round tables, panel discussions and original papers offer the membership introduction to new areas and developments in the film field. A highlight of the annual session is the presentation of awards for outstanding films produced by the university film makers.

Officers of the organization are:

John R. Winnie, University of Iowa, *President*

Wilbur Blume, University of Southern California, *Vice-President*

Roland J. Faust, Indiana University, *Secretary-Treasurer*

Communication regarding membership should be addressed to the Secretary. Information concerning Journal subscription or manuscript submission should be sent to the Editor, Lu Snyder, Audio-Visual Center, Syracuse University, Syracuse, N.Y.—*John R. Winnie.*

Obituary

Louis Gerard Pacent, an early researcher for sound motion pictures, died in April at the age of 58.

Mr. Pacent began experimenting with wireless transmission when he was a youth and he had his own amateur station when he was 16. In 1913 he was a communicator in the Naval Militia and in 1917 he served aboard the U.S.S. Gloucester. Also during World War I he worked on the development of military communications equipment.

After that war he organized the Pacent Electric Company, Inc., which was active in the design and production of electric and radio facilities for General Electric, Westinghouse, Western Electric, RCA and the Government. Before World War I he was influential in encouraging and instructing amateurs and in 1921 the first short-wave transatlantic message was transmitted to Scotland from Greenwich, Conn., on 200 meters which had been Mr. Pacent's suggestion.

Mr. Pacent was active in research for sound motion pictures in the 1920's. He is reported to have designed the first all power-operated motion picture sound equipment while a consultant for Warner Brothers Pictures, the equipment having been installed in 1928.

At the time of his death he was president of the Pacent Engineering Corp., a firm which he had founded 20 years ago. The corporation developed portable sound reproducers, inter-office communicating equipment, high-fidelity radio and public address systems.

In 1946 Mr. Pacent was given a Certificate of Appreciation by the War Department in recognition of his firm's valuable assistance to the Signal Corps during World War II.

He was a native of New York and was graduated in 1916 from Pratt Institute of Technology with the degree of Industrial Electrical Engineer. He was the author of many papers and books on communications engineering. He was a Fellow of this Society and also of the Institute of Radio Engineers, and a member of the American Institute of Electrical Engineers. In 1951, he received the Marconi Memorial Medal of Achievement from the Veteran Wireless Operators Association.

New Members

The following members have been added to the Society's rolls since those last published. The designations of grades are the same as those used in the 1950 Membership Directory.

Honorary (**H**) Fellow (**F**) Active (**M**) Associate (**A**) Student (**S**)

Aicher, John W., SRT-TV Studios. **Mail:** 400 W. 56 St., New York 19, N.Y. (**S**)

Bailey, G. C., Export Sales, Eastman Kodak Co., Rochester, N.Y. (**A**)

Bailey, James H., Projectionist, Warner Brothers Studio. **Mail:** 813 N. Rose St., Burbank, Calif. (**A**)

Behrmann, Louis L., Photographic Technologist, U.S. Naval Research Laboratory. **Mail:** 12240 Viers Mill Rd., Silver Spring, Md. (**A**)

Belinkoff, Irving R., Junior Engineer, Federal Manufacturing & Engineering Corp. **Mail:** 449 Beach 67 St., Arverne, L.I., N.Y. (**A**)

Bernier, Maj. Robert V., U.S. Air Forces. **Mail:** 4505 Arcadia Blvd., Dayton 10, Ohio. (**M**)

Bessor, John O., Jr., Motion Picture Cameraman, Byron, Inc. **Mail:** 1537 Roosevelt Ave., Falls Church, Va. (**A**)

Bordelay, Jack F., Director, Cameraman, Syracuse University. **Mail:** 108 Comstock Ave., Syracuse 10, N.Y. (**A**)

Braunstein, Simeon, Director, Photo Section, Engineering Research Div., New York University. **Mail:** 2666 Valentine Ave., New York 58, N.Y. (**M**)

Buckner, W. C., Vice-President and Chief Engineer, NECO, Inc. **Mail:** 12132 Herbert St., Culver City, Calif. (**M**)

Carrington, H. K., Motion Picture Producer, Nationwide Pictures, Melba Theatre Bldg., Dallas, Tex. (**A**)

Cass, Lewis S., Recording Technician, Paramount Pictures. **Mail:** 240 W. 98 St., New York, N.Y. (**A**)

Cooper, James E., Motion Picture Film Editor and Projectionist, The Calvin Co. **Mail:** 3208 Highland Ave., Kansas City, Mo. (**A**)

Creamer, C. C., Partner, Theatre Equipment Business. **Mail:** 75 Glenwood Ave., Minneapolis, Minn. (**A**)

Dellins, Bert A., Motion Picture and Sound Salesman, Fotoshop, Inc. **Mail:** 112–41 — 72 Rd., Forest Hills 75, L.I., N.Y. (**A**)

Diament, Clifton L., Motion Picture Laboratory Technician, Byron, Inc. **Mail:** 1017 Dashill Rd., Falls Church, Va. (**A**)

Dickerson, Malon, Chemical Physicist, Southwest Research Institute. **Mail:** 8500 Culebra Rd., San Antonio 6, Tex. (**A**)

Dratch, Nicholas, Quality Control Engineer, Bolsey Corp. of America. **Mail:** 1569 Metropolitan Ave., Bronx 62, N.Y. (**A**)

Faber, John, Technical Representative, Eastman Kodak Co. **Mail:** 5 Edgewater Dr., Denville, N.J. (**M**)

Faust, A. Donovan, Assistant General Manager, WDTV (Allen B. DuMont Laboratories, Inc.). **Mail:** 121 Abbeyville Rd., Pittsburgh 28, Pa. (**A**)

Fielding, Raymond, University of California at Los Angeles. **Mail:** 1333½ Federal Ave., Los Angeles 25, Calif. (**S**)

Freedman, Myron L., General Manager, Crescent Film Laboratories, Inc. **Mail:** 7510 N. Ashland Ave., Chicago 26, Ill. (**M**)

Garcia, Orlando M., Custom House Broker. **Mail:** Habana #412 (Altos), Entre Obispo y Obrapia, La Habana, Cuba. (**A**)

Geis, Donald C., Sound Engineer, Hearst Metrotone News, Inc. **Mail:** 5939 Forest Glen Ave., Chicago 30, Ill. (**A**)

Geller, Gilbert, Cameraman, Films for Industry. **Mail:** 160–37 Highland Ave., Jamaica, L.I., N.Y. (**A**)

Gimborn, Charles J., Jr., Chief Motion Picture Photographer, WCAU-TV. **Mail:** 412 W. Delphine St., Philadelphia 20, Pa. (**A**)

Giovanelli, Frank, Cameraman (Animation), Consolidated Film Industries, Inc. **Mail:** 2716 Marion Ave., Bronx 58, N.Y. (**M**)

Giovanelli, Frank Jr., Consolidated Film Industries, Inc. **Mail:** 2716 Marion Ave., Bronx 58, N.Y. (**A**)

Glandbard, Max, Producer, Filmwright Productions, Inc. **Mail:** 195 Mohawk Dr., River Edge, N.J. (**A**)

Goldsmith, Charles B., Sound Technician, Radio Corp. of America. **Mail:** 307 S. Kenter Ave., West Los Angeles, Calif. (**A**)

Goldstein, Raphael L., Projectionist, Television Film Editor, South City Drive In, WFIL-TV. **Mail:** 1812 S. Fifth St., Philadelphia, Pa. (**A**)

Griffiths, Peter H., Electronic Engineer. **Mail:** 28 Eccleston Rd., South Shore, Blackpool, England. (**A**)

Grove-Palmer, Clifford O. J., Research Engineer, British Admiralty, Royal Naval Scientific Service. **Mail:** 59 Kings Rd., Rosyth, Dunfermline, Fife, Scotland. (**M**)

Harvard, Emile A., Motion Picture Producer, Cameraman, Harvard Productions. **Mail:** Box 1597, Tel Aviv, Israel. (**A**)

Henion, William C., Project Engineer, USAF Projection Equipment, Box 8015, Area B, Photo Reconnaissance Laboratory, WCE, WADC, WPAFB, Dayton, Ohio. (**A**)

Henning, Clarence G., Photographic Technician, David White Co., 315 W. Court St., Milwaukee 12, Wis. (**M**)

Holloway, F. P., Carbon Development Engineer, National Carbon Co., Div. of U.C. & C. Corp., Fostoria, Ohio. (**M**)

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Kern, Albert W., Assistant Cameraman, Free-lance. **Mail:** 49 County Center Rd., White Plains, N.Y. (**A**)

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Mamas, Harry, Cameraman, Telecraft Film Productions. **Mail:** 17 Adams St., Medfield, Mass. (**A**)

Marchiel, Stanley, Sensitometric Sound Control, Paramount Pictures, Inc. **Mail:** 81 Oakland St., Brooklyn 22, N.Y. (**M**)

Marks, Jesse, Contract Negotiator and Administrator, U.S. Navy Motion Picture Exchange, Bldg. 311, N.Y. Naval Shipyard, Brooklyn 1, N. Y. (**M**)

Martens-Hughes, Margot, Visual Aids Specialist, IIA, U.S. Dept. of State, 1778 Pennsylvania Ave., Washington, D.C. (**A**)

Merriken, George T., Production Manager, Byron, Inc. **Mail:** 112 Lynmoor Dr., Silver Spring, Md. (**A**)

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Moe, Sigurd M., Sound Recording Technician, U.S. Navy. **Mail:** Combat Camera Groups Pacific, Com Nav FE, FPO San Francisco, Calif. (**A**)

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Pabst, Glenn C., Photographer, Bell Aircraft Corp. **Mail:** 17 Raymond Pl., Hamburg, N.Y. (**A**)

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Plakun, Bernard D., Technical Writer, General Precision Laboratory, Inc. **Mail:** 15 Maywood Ave., Port Chester, N.Y. **(A)**

Portalupi, Piero, Director of Photography, Lux Film. **Mail:** Viale Bruno Buozzi, 83 int F, Rome, Italy. **(M)**

Pratt, Harry E., Sales Representative, W. J. German, Inc., 6700 Santa Monica Blvd., Hollywood 38, Calif. **(M)**

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Russey, Elwood M., Vice-President, Byron, Inc. **Mail:** Box 45, R.F.D. #1, Vienna, Va. **(M)**

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Smith, Newland F., Television Engineer, WOR-TV, General Teleradio, Inc. **Mail:** Spruce St., Riverside, Conn. **(M)**

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Smith, Thomas W. B., Regional Geologist, Gulf Oil Corp. **Mail:** Box 1166, Pittsburgh 30, Pa. **(A)**

Spafford, Ronald W., Assistant to General Sales Manager, Industrial Products, National Carbon, Ltd. **Mail:** 345 Kingsdale Blvd., Willowdale, Ont., Canada. **(A)**

Speed, William C., President, Audio Devices, Inc., 444 Madison Ave., New York 22, N.Y. **(M)**

Stehney, Michael C., Photographer, Director, Sarra, Inc. **Mail:** 18411 Dundee, Homewood, Ill. **(M)**

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Taris, Charles M., Member, Technical Staff, Bell Telephone Laboratories, Inc. **Mail:** 11 Adams Ave., Cranford, N.J. **(A)**

Taylor, Barney L., Chief Dental Technician, U.S. Navy. **Mail:** 534 Eleventh St., NHA2, Honolulu 18, Hawaii. **(A)**

Teasley, Ernest, Secretary-Treasurer, EDL Co. **Mail:** Miller Station, Garv 5, Ind. **(A)**

Thorn, Thomas C., Laboratory Manager, Pathescope, Ltd. **Mail:** 29 Florida Rd., Thornton Heath, Croydon, Surrey, London, England. **(M)**

Todaro, Fred G., Design and Engineering, Negative and Positive Processing Equipment, Color Service Co. **Mail:** 320 Albemarle Rd., Brooklyn, N.Y. **(M)**

Tydings, Kenneth S., Photographic Author, Podiatrist. **Mail:** 110 E. Chester St., Long Beach, N.Y. **(A)**

Vance, Robert G., Cameraman, Byron, Inc. **Mail:** Route 4, Box 325, Alexandria, Va. **(A)**

Vanoni, Vito A., Professor, California Institute of Technology, Hydro Laboratory, Pasadena 4, Calif. **(A)**

Vary, Willard E., Head, Physical Tests Div., U.S. Naval Photographic Center. **Mail:** 2107 Ft. Davis St., S.E., Washington 20, D.C. **(M)**

Webb, Harry, University of Minnesota. **Mail:** 813 University Ave., S.E., Minneapolis, Minn. **(S)**

Weiss, J. Paul, Research Physicist, Photo Products Dept., E. I. du Pont de Nemours & Co., Inc. **Mail:** 908 New England Dr., Westfield, N.J. **(M)**

Young, H. A., Electrical Design Engineer, RCA Victor Div. **Mail:** 702 N. Naomi, Burbank, Calif. **(A)**

Zambuto, Mauro, Technical Director, Motion Picture Studio, Scalera Films. **Mail:** Via Cavour 114, Rome, Italy. **(M)**

Zan, Aung Phaw, University of Southern California. **Mail:** 1072½ W. 31 St., Los Angeles 7, Calif. **(S)**

CHANGES IN GRADE

Cruse, Andrew W., **(A)** to **(M)**

DuVall, John W., **(A)** to **(M)**

King, Roy D., **(A)** to **(M)**

Paul, Morrison B., **(A)** to **(M)**

Petrasek, A. G., **(A)** to **(M)**

Potter, Johnson, **(A)** to **(M)**

Valentine, Fred, **(S)** to **(A)**

Wadlow, Huston E., **(A)** to **(M)**

Wendt, Paul R., **(A)** to **(M)**

Willey, Lyle E., **(A)** to **(M)**

Book Reviews

IES Lighting Handbook (Second Edition)

Published (1952) by The Illuminating Engineering Society, 1860 Broadway, New York 23. i-xiii + 740 pp. + 37 pp. appendix + 24 pp. index + 172 pp. advt. 482 illus. + numerous tables. 6 × 9 in. Price $8.00.

This volume fills a long-standing need for a compendium which presents essential lighting theory and data in condensed and readable form. The new edition represents an extensive revision of the original 1947 publication, more than 75% of the material, according to the editors, being new or completely rewritten. Some 200 pp. of text have been added, and data have been revised in line with the best current values. Bibliographies at the ends of the sections have been extended to include material published as recently as September 1951.

The first part of the Handbook includes sections dealing with physics of light, light and vision, standards and nomenclature, measurement of light, color, light control, daylighting, light sources and lighting calculations. The second part is devoted to applications, with discussions of interior and exterior lighting, sports lighting, street and highway illumination, aviation and transportation lighting, miniature lamps, and photographic, reproduction, projection, television and radar screen lighting. A section on miscellaneous applications covers uses of ultraviolet and infrared energy. Illumination requirements of the various lighting fields and methods for fulfilling them are well covered.

The *Handbook* is, of course, designed primarily to serve the needs of the illuminating engineer. SMPTE members will find it a handy compilation of "time-tested" methods and techniques, although, as is natural in a volume covering the entire lighting field, material of direct interest to the SMPTE member receives rather brief treatment. The section on light sources includes two pages on the carbon arc, as well as tables giving performance characteristics of d-c and flame-type carbons. The discussion on lighting for motion picture photography includes descriptions and illustrations of incandescent and carbon-arc lamps commonly used for set lighting, tables showing beam characteristics, and figures giving spectral energy distributions. Some eight pages are devoted to picture projection lighting with paragraphs on brightness levels, screen surfaces, viewing conditions, projection booth design, and light output of typical carbon-arc systems. There are short discussions of television studio lighting and lighting of drive-in and motion picture theaters.

The concise summaries contained in the *Handbook* are supplemented through bibliographies appended to each section. An appendix contains conversion factors and equations, I.C.I. tristimulus computation data, and tables of selected ordinates. A detailed subject index, index tabs, and a complete table of contents for each section facilitate access to specific information. The paper used is of high quality, the print is larger and more legible than that usually found in handbooks, and illustrations and photographs have been provided with unusual generosity.

As an authoritative and convenient summary well provided with guides for further reading, the *IES Lighting Handbook* should find a place on the desk of every engineer required to deal with broad problems of lighting. The sections on light sources, measurements and calculations will be especially useful to the SMPTE member, though for detailed information on problems of motion picture studio, theater and projection lighting, it will still be necessary to consult the publications of the SMPTE.—*M. S. Wright*, National Carbon Research Laboratories, Cleveland, Ohio.

Basic Electron Tubes

By Donovan V. Geppert. Published (1951) by McGraw-Hill, 330 W. 42 St., New York 36. 332 pp. 257 illus. 6 × 9 in. Price $5.00.

As the title implies, this book deals with the principles of operation of well-known vacuum tubes.

Written as a text for undergraduates, it fulfills the requirement for lucidity by an understandable style and a novel arrangement of subject matter. Undoubtedly founded on the axiom that an interested student learns rapidly and well, the author has reversed the conventional order of presenting his subjects.

Instead of starting with a few abstract statements and a welter of mathematics, he presents first the physical nature of the easily recognized practical tube, giving qualitative theory in explanation. From this he goes to the electrical nature of the tube, presenting the characteristic curves and an illustrative circuit. The theory is often explained with the assistance of the rubber-membrane rolling-marble model, which is shown in a well-executed three-dimensional illustration.

By this time even the interested tyro has a good conception of the device and then the author launches into the mathematical analysis that must be a part of any mature treatment. This is given meaning by sample calculations of problems likely to be faced in practice. Both cgs and mks units are used and the relation between the two systems explained.

The tubes treated are indicated by the chapter headings: 1. High-vacuum and Gas Phototubes; 2. High-vacuum Thermionic Diodes; 3. High-vacuum Triodes; 4. Tetrodes and Pentodes; 5. Beam-power Tetrodes; 6. Cathode-ray Tubes; 7. Glow-discharge Tubes; 8. Thermionic Gas Diodes; 9. Thyratrons; 10. Mercury-pool Arc Rectifiers; and 11. Ignitrons.

A useful feature of the book is a summary of the practical consequences of altering tube parameters. For instance, in the case of the triode, nine numbered sentences give the alteration of electrical characteristics for stated alterations of the tube structure. This tends to establish fundamentals in the mind of the student or engineer and serves as a focal point for reference when memory fades.

Additional references and problems are to be found at the end of each chapter.

The book is the fourth in a series of fourteen on electrical and electronic engineering, for which the well-known and esteemed Dr. Frederick Emmons Terman is Consulting Editor. This fact accounts for the title and the absence of discussion of the microwave tube. This device is more often a part of the circuit than a separate entity and so is treated in another book of the series.

The book would appear to be useful to nearly all motion picture and television engineers as a convenient reference.—*Harry R. Lubcke*, Consulting Engineer, 2443 Creston Way, Hollywood 28, Calif.

Bases Techniques de la Television

By H. Delaby. *In French.* Published (1951) by Editions Eyrolles, 61, Blvd. Saint-Germain, Paris (V^e). 340 pp. 273 illus. $6\frac{1}{2} \times 9\frac{3}{4}$ in. Paper bound. Price 2,200 fr. (approx. $6.30).

The principal interest of a reader of this *Journal* in a technical book in a foreign language lies in whether, having surmounted the difficulties of translation, the reader will obtain information on other methods and devices that cannot be obtained in his native language. This reviewer's interest was largely in the practical details of the controversial 819-line French television system and its operation in the same studio plant with a 625- or 455-line system. Unfortunately, this book, although excellent in its way, is not informative about such details.

With its companion volume by the same author *Principes Fondamentaux de Television*, to which frequent reference is made, this book serves as an adequate text for a course in television at what would be in the United States, college senior level. The general principles of video amplifiers, synchronizing generators, studio cameras, film cameras, transmitters, receivers and antennas are covered in varying degrees of detail. Studio control equipment rates 8 pp.; the receiver, 24 pp.; and the transmitting antenna, 54 pp.; to cite a few

examples of the somewhat strange balance between topics. This is perhaps an unfair criticism, since much material of importance, such as the whole subject of scanning generators, is apparently covered in the companion volume.

There are several general texts on television published in the United States which cover in more detail essentially everything included in this book. Actually, over half the references are to technical magazines and books in English.

The one section which contains information not available in *American* (as distinguished from English-language) texts is that on the television transmission of film. The use of flying-spot scanners with continuously-moving film, and the peculiar problems of 50-cycle power supplies are discussed in reasonable detail. From the references given, however, this reviewer had the impression that, if he had obtained a copy of the proceedings of the "Congres de Television" which was held at Paris in 1948, he would be in a better position to learn about French television methods than by a study of H. Delaby's book.—*S. W. Athey*, General Precision Laboratory, Inc., Pleasantville, N.Y.

Television Principles

By Robert B. Dome. Published (1951) by McGraw-Hill, 330 W. 42 St., New York 36. i-xii + 281 pp. + 9 pp. index. 170 illus. 6 × 9 in. Price $5.50.

The material for this book was taken from a series of lectures which formed one of the radio training courses for engineers of the General Electric Co.

The book covers all stages of television transmission and reception. There are chapters on scanning and reproduction, transmitting apparatus, antennas for transmission and reception, propagation and relays, RF input circuits and noise factors, IF amplifiers, picture second detector and the scanning system. The author has followed the television signal from the camera through the receiver.

Mathematical development of many principles is shown and practical problems using these principles are given. The design problems make use of many of the latest types of tubes.

Schematic circuits and diagrams are used and there are no pictures or diagrams of commercial installations or equipment. The book is about engineering rather than operations and is concise and to the point.

On the transmitting side Mr. Dome has lightly covered the operation of the different pickup tubes and antennas. He has paid particular attention to video frequency amplifiers and picture transmitters.

On the receiving end he has emphasized radio frequency input circuits, intermediate frequency amplifiers and scanning circuits. The chapter on RF input circuits includes the cascode amplifier and has material on noise factors for each circuit.

A miscellany chapter covers such things as d-c restoration, automatic gain control, overall fidelity and the author's own intercarrier sound system.

The book is an excellent work and is a welcome addition to the McGraw-Hill Television Series.—*Otis S. Freeman*, Asst. Chief Engineer, WPIX, 220 E. 42 St., New York 17.

Application of the Electronic Valve in Radio Receivers and Amplifiers (Vol. II)

By B. G. Dammers, J. Haantjes, J. Otte, and H. Van Suchtelen. Published (1951) by N. V. Philips' Gloeilampenfabrieken, Eindhoven, Netherlands. Distributed in U.S.A. by Elsevier Press, Inc., 402 Lovett Blvd., Houston 6, Texas. i-xviii + 425 pp. + 6 pp. index. 343 illus. 6 × 9 in. Price $7.75, English ed.

This is the second volume of a trilogy being put out by the famous Philips of Eindhoven on the uses of tubes in receivers and amplifiers, principally the former. Volume I covered rf and if amplification, frequency changing, interference and distortion, and detection. The present volume is devoted to af voltage and power amplification and power supplies. That being the case, it is of considerable value to motion picture workers, even though it is primarily concerned with receivers.

The treatment is by no means superficial and is entirely applicable to amplifiers and power supplies for any purpose. Tube performance is analyzed mathe-

matically and graphically and design criteria given for standard circuits. An interesting section, not strictly within the purview of tubes is on design of af transformers.—*Richard H. Dorf*, Audio and TV Consultant, 255 W. 84 St., New York 24, N.Y.

Agfacolor Process, a Short Bibliography

Compiled by Alexis N. Vorontozoff (1951), 25 mimeographed pages, $8\frac{1}{2} \times 11$ in. Available from the Author, 10 rue Mademoiselle, Paris. Price, $0.50 plus postage.

Mr. Vorontozoff has done a noteworthy job in compiling 236 references on the Agfacolor Process which he has published alphabetically according to author, with a cross-reference list according to subject. He has indicated also whether or not the reference has been consulted directly, the language of the original paper, references to abstracts of each paper published in other periodicals, availability of reprints, translations, etc. The bibliography covers all aspects of the Agfacolor Process, including numerous references applicable to the motion picture field.—*Lloyd E. Varden*, Pavelle Color, Inc., 533 W. 57 St., New York 19, N.Y.

Transmitting Valves

By J. P. Heyboer and P. Zijlstra. Published (1951) by N. V. Philips' Gloeilampenfabrieken, Eindhoven, Netherlands. Distributed in U.S.A. by Elsevier Press Inc., 402 Lovett Blvd., Houston 6, Texas. i-xii + 281 pp. + 2 pp. index. 256 illus. 6×9 in. Price $6.25, English ed.

This volume is Book VII of the fast-growing Philips library. It is concerned with the characteristics of transmitting tubes—pentodes, tetrodes, and triodes in which transit-time effects are negligible—and the circuits in which they are used. Chapters give thorough mathematical design treatments of tube construction, rf power amplifiers, oscillators and frequency multipliers, as well as some data on special uses such as vhf feedback circuits. One of the appendixes contains a table of technical data on Philips transmitting tubes. As with the receiver book from Philips (reviewed above), the translation is excellent, the language clear and concise.—*Richard H. Dorf*, Audio and TV Consultant, 255 W. 84 St., New York 24, N.Y.

Positions Wanted

Photographic Chemist: 3 yr. experience black-and-white and color film laboratory practice and quality control. Familiar with all commercial color processes and sensitometry. Have conducted research in new processing methods. Position desired in research or development on new products and processes. Will relocate. Write M-52, c/o Lichtig, 3758 Tenth Ave., New York 34, N.Y.

Production, TV or Motion Picture: NYU BA in motion picture and TV production; participated in productions as director and unit mgr; experience as motion picture sensitometrist; at present motion picture negative assembler and cutter; worked swing shift while attending college; licensed 35mm projectionist; single, 29, veteran, resumé on request; go anywhere. Harold Bernard, 560 Eastern Pkwy, Brooklyn 25, N.Y.

Sound mixer and transmission engineer: 5 yr experience 35mm magnetic and optical 16mm optical and disc recording systems. As mixer has experience stage recording and re-recording; in transmission has installed a recording channel complete from design to operation, also maintenance. Will accept position any geographic location. Write L-30, c/o Fifer, 143 Church St., Phoenixville, Pa.

Motion pictures in color depend on the engineers' knowledge of the "Principles of Color Sensitometry." A 72-page article bearing that title and prepared by the Color Sensitometry Committee appeared in the *Journal* for June 1950. Attractive reprint copies may be purchased for $1.00.

Meetings

72nd Semiannual Convention of the SMPTE, Oct. 6-10, Hotel Statler, Washington, D. C.

Other Societies

Society of Photographic Engineers, Photographic Instrumentation Symposium, June 4–5, Naval Ordnance Laboratory, White Oak, Md.

American Institute of Electrical Engineers, Summer General Meeting, June 23–27, Hotel Nicollet, Minneapolis, Minn.

American Physical Society, June 30–July 3, Denver, Colo.

National Audio-Visual Association, Convention and Trade Show, Aug. 2–5, Hotel Sherman, Chicago, Ill.

University Film Producers Association, Annual Meeting, Aug. 11–15, Syracuse University, Syracuse, N. Y.

Photographic Society of America, Annual Convention, Aug. 12–16, Hotel New Yorker, New York

American Institute of Electrical Engineers, Pacific General Meeting, Aug. 19–22, Hotel Westward Ho, Phoenix, Ariz.

International Society of Photogrammetry, Conference, Sept. 4–13, Hotel Shoreham, Washington, D.C.

American Standards Association, Third National Standardization Conference, Sept. 8–10, Museum of Science and Industry, Chicago, Ill.

Illuminating Engineering Society, National Technical Conference, Sept. 8–12, Edgewater Beach Hotel, Chicago, Ill.

Biological Photographic Association, Annual Meeting, Sept. 10–12, Hotel New Yorker, New York

National Electronics Conference, Annual Meeting, Sept. 29–Oct. 1, Sherman Hotel, Chicago, Ill.

Optical Society of America, Oct. 9–11, Hotel Statler, Boston, Mass.

American Institute of Electrical Engineers, Fall General Meeting, Oct. 13–17, New Orleans, La.

American Standards Association, Annual Meeting, Nov. 19, Waldorf-Astoria, New York

Six American Standards have been added to the Motion Picture Set of 60 which the Society has had available for sale. To holders of the present set the Society has made available the seven new standards: PH22.11-1952, PH22.24-1952, PH22.73-1951, PH22.74-1951, PH22.76-1951, PH22.77-1952 and PH22.82-1951. The price is $1 plus 3% sales tax on deliveries in New York City.

The new set of 67 standards in a heavy three-post binder with an index is available at $14.50 plus 3% sales tax on deliveries in New York City; foreign postage is $.50 extra.

All standards **in sets only** are available from Society Headquarters. Single copies of any particular standard must be ordered from the American Standards Association, 70 E. 45th St., New York 17, N.Y.

Back issues of the Journal available: A set of Journals from January 1945 through 1951 is available at $15.00 plus packing and carrying costs from Richard W. Maedler, 32–52 — 46 St., Long Island City 3, N.Y.

Back issues of the Journal available: Don Canady, 5125 Myerdale Drive, R.R. 15, Cincinnati 36, Ohio, desires to dispose of a complete set, in excellent condition, from January 1930 to date, plus one issue of September 1928. Anyone interested in acquiring the complete set should communicate directly with Mr. Canady.

New Products

Further information about these items can be obtained direct from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of these items does not constitute endorsement of the products.

The Tener has been announced as a 25th Anniversary Topper by Mole-Richardson Co., 937 N. Sycamore Ave., Hollywood 38, Calif. This 10,000-w lamp, Type 416, is described with these specifications: constructed of sheet metal with interlocking channels for ventilation; condenser, special 20-in. Fresnel, 15° to 40° divergence; mirror, Alzak aluminum and completely adjustable; socket, Mogul Bipost; globe, 10,000-w G96 Mogul Bipost; focusing by handle on front or back; cable, 25-ft loom-covered with stage plug and furnished separate from lamp for attachment with pin plugs; switch, 100-amp; weight, 117-lb head, 16-lb cable and 37-lb pedestal. Accessories, sold separately but also described in a Mole-Richardson brochure, are: barn door, diffuser frame and shutter.

Fundamentals of Magnetic Recording is a 50-page handbook covering the subject chiefly under these headings: magnetic recording method, magnetic relations, bias, erasing, output, uniformity of output, frequency response, distortion and noise, modulation noise, tape construction, head wear, printing, splicing, selecting a tape recorder, and maintenance. Written by C. J. LeBel, Vice-President of Audio Devices, it is available at no charge upon a written request to Audio Devices, Inc., 444 Madison Ave., New York 22, N.Y.

Correction and Amplification: In the description of a lightweight sound-proof blimp, p. 274 of the March 1952 *Journal*, the manufacturer of the Arriflex camera was erroneously noted. The Arriflex is made in Germany by Arnold & Richter K.G., 89 Tuerkenstrasse, Munich, Western Zone; and the sole agents in North America are Kling Photo Supply Corp., 235 Fourth Ave., New York 3, N.Y.

SMPTE Officers and Committees: The roster of Society Officers and the Committee Chairmen and Members were published in the April *Journal.*

The Ansco Color Negative-Positive Process

By HERMAN H. DUERR

The basic principles of the Ansco Color Negative-Positive Process are outlined. The paper deals with the essential characteristics of the color film materials used for the process and outlines the printing and processing steps required. Methods used to comply with the requirements of the motion picture industry in regard to color dupes for optical effects, protection masters, color negative master dupes, and color release printing are described. Requirements of sound and procedures to produce silver sound tracks are discussed.

In 1945,[1] the Ansco Color Process for professional motion pictures was proposed. This process was based on the principle of reversible development of monopack materials. Several motion pictures have been produced using this process. It was realized, however, that a color process using the negative-positive approach would be preferable for a number of reasons. In the first place, such a process would follow more closely the long established black-and-white practices of the motion picture industry. More important, however, a color film process using the negative-positive cycle is superior due to the higher speed attainable and the considerably greater latitude in exposure, processing and printing.

The Color Negative-Positive process, however, presented many problems, particularly in regard to methods of providing dupes for optical effects, protection masters and other essential requirements for the production of feature motion pictures. These problems have now been satisfactorily solved and the Ansco Color Negative-Positive process will now replace the older process using film types 735 and 732, requiring reversible development.

The Ansco Color Negative-Positive Process, like the earlier reversal process, is a subtractive color process, using the principle of color-forming development.

There are three different 35mm color film materials involved in the process:

Color Negative Film Type 843,
Color Dupe Negative Film Type 846, and
Color Positive Release Printing Film Type 848.

In addition to these color film materials, a panchromatic fine grain dupe film, such as the Eastman Panchromatic Sepa-

Presented on October 18, 1951, at the Society's Convention at Hollywood, by Herman H. Duerr, Ansco Division of General Aniline & Film Corp., Binghamton, N.Y.

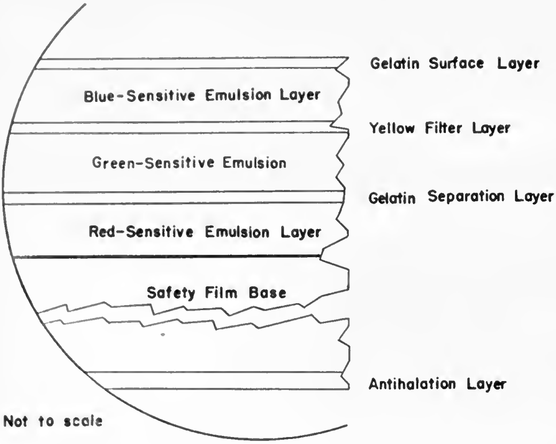


Fig. 1. Scheme of layer arrangement of Ansco Color Negative, Type 843, before processing.

ration Film, Type 5216, can be used for making separations.

The three multilayer color film types used in the negative-positive cycle are similar in structure, although quite different in other characteristics.

Figure 1 shows the layer arrangement typical for the three color film types used in the process. The conventional layer arrangement, with a red-sensitive bottom layer, a green-sensitive middle layer and a blue-sensitive top layer, is being used. This figure illustrates the Color Negative Film Type 843 before processing.

As has been described before,[2] the three colors, cyan, magenta and yellow, in the Ansco Color Process are formed in their respective layers during *one* color developing step. It is one of the important characteristics of the Ansco Color Process that the nondiffusing, colorless color couplers are dissolved and uniformly distributed in the gelatin of the photographic emulsion layers and completely surround the individual light-sensitive silver halide grains. After exposure and during the color development, the developing agent becomes partially oxidized by reducing exposed silver halide grains to metallic silver. The partially oxidized developing agent reacts with the color couplers to form dye deposits. The oxidized color developing agent is soluble and can move freely in the layer. In order to produce a dye image in closest proximity with the originally exposed grain, it is, therefore, important that the color coupler surround the silver halide grain so that the coupling reaction can take place truly *in situ* with the silver halide grain. This characteristic of the Ansco Color Process is important and is responsible

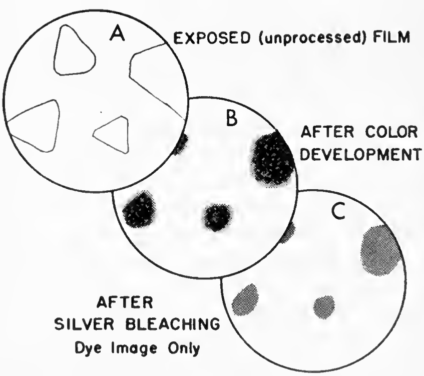


Fig. 2. Scheme of three stages in the processing of Ansco Color Film:

A. Silver halide grain before color development;

B. Silver grain after color development; and

C. Grain after silver bleach

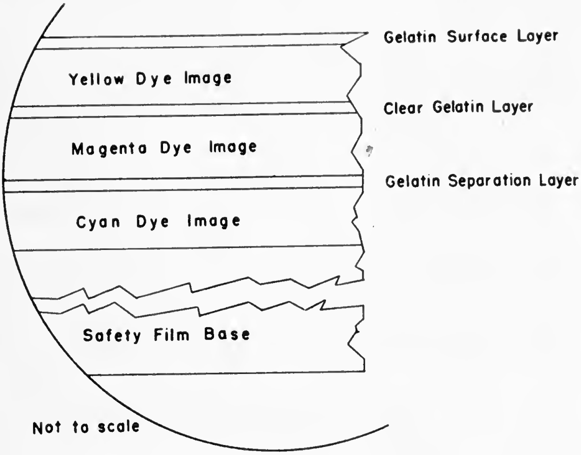
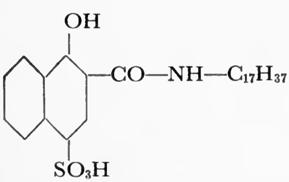


Fig. 3. Scheme of color negative layers after color processing.

for the good image sharpness and definition.

A schematic illustration of the mechanism of dye image formation taking place in closest proximity to the exposed silver halide grains is shown in Fig. 2. The Ansco color couplers are immobilized in the emulsion layers by means of the specific chemical configuration of the color coupler molecules. To provide the characteristics of complete solubility and at the same time immobility and nondiffusing properties, the molecular structure has been arranged in such a way that a fatty acid molecule of large molecular size, through a short linkage, is chemically combined with the dye coupler molecule.[3] The fatty acid molecule acts somewhat like an anchor, preventing the diffusion of the dye coupler and of the formed dye image within the layer, as well as from one layer to another.

A typical cyan colorformer of this configuration, with substitution referred to as "fat-tail," is:



Ansco Color Negative Film, Type 843

Camera Requirements: The Ansco Color Negative Film, Type 843, can be exposed in conventional motion picture cameras as they are used for black-and-white photography. The only additional requirement is that, for maximum image definition, the lenses used should have good color correction.

Film Characteristics: The layer arrangement of the Color Negative Film, Type 843, before processing has been shown in Fig. 1. The layers after processing are shown in Fig. 3.

More recently the Type 843 film has been supplied on gray base instead of on clear base with the soluble antihalo back layer, and results regarding halation in motion picture practice have been quite satisfactory. The gray base does not interfere with the subsequent printing operations and the absence of a soluble back layer on the negative film has certain advantages in processing.

Sensitometry: The sensitometric curves of the three emulsion layers of the Color Negative Film, Type 843, are illustrated in Fig. 4. When developed to the proper contrast for direct printing on Color Positive, Type 848, or for the preparation of black-and-white tricolor

separations, the gamma values for the three layers, measured as integral densities on the Macbeth-Ansco Color Densitometer Model 12, should be approximately as follows:

Blue-sensitive layer (yellow) . .	1.25
Green-sensitive layer (magenta) .	1.00
Red-sensitive layer (cyan) . . .	1.00

Spectral Sensitivity: The spectral sensitivity of the color negative film is shown in Fig. 5. The sensitivity peaks are at 450, 555 and 655 mμ, respectively. The film is balanced for light of daylight

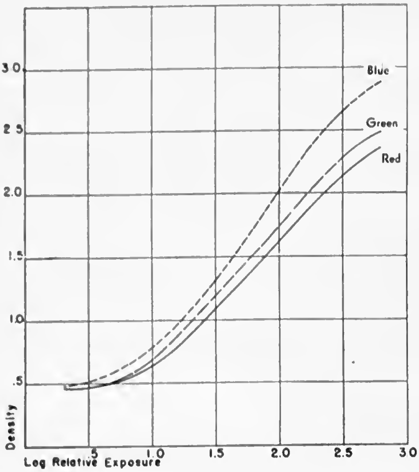
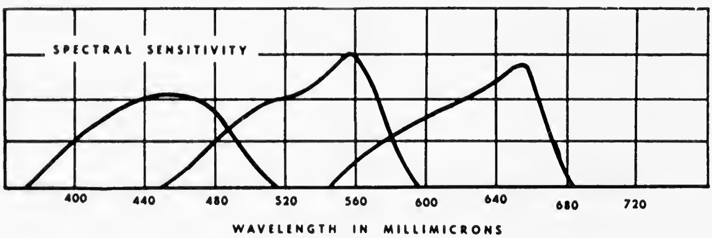


Fig. 4. Integral density curves of color negative film, Type 843.

Fig. 5. Spectral sensitivity of color negative film, Type 843.



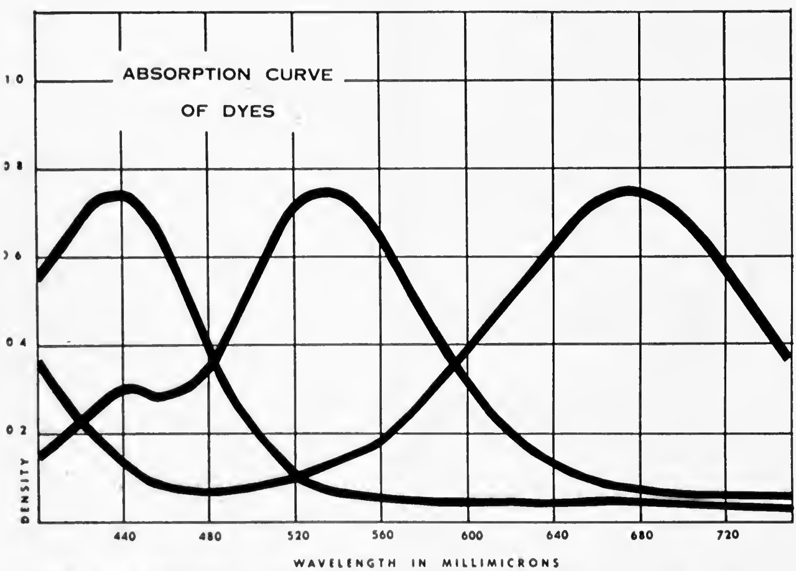


Fig. 6. Absorption characteristics of color negative film, Type 843.

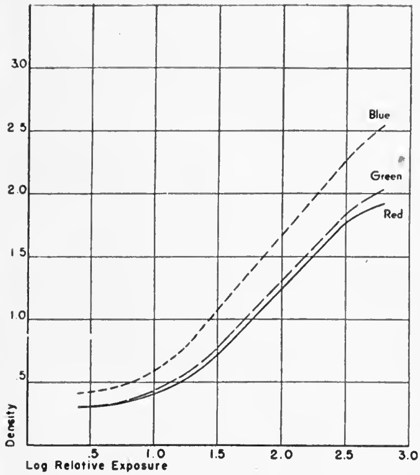


Fig. 7. Integral density curves of color dupe negative film, Type 846.

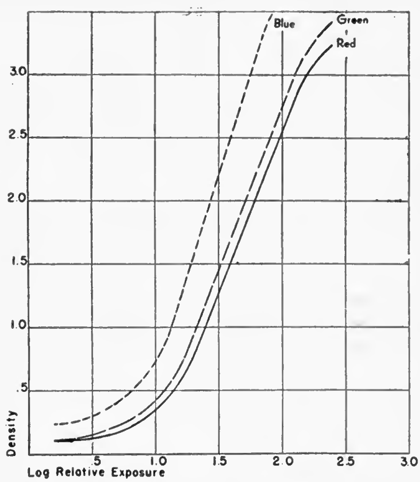


Fig. 8. Integral density curves of color positive release printing film, Type 848

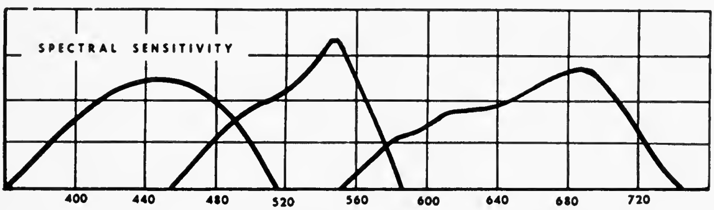


Fig. 9. Spectral sensitivity of color positive printing film, Type 848.

quality. For interior illumination the overall color balance should be approximately 5400 K. While the overall color balance is not critical, it is important that the different light sources on a set be balanced to the same spectral quality. The use of ultraviolet filters, such as Ansco UV-16 or Wratten Filter No. 1, for outdoor exposures and indoor exposures with arc lights is recommended.

Absorption Characteristics: The dye images recorded in the color negative film are in colors complementary to the colors of the original. The absorption characteristics of the dyes in the color negative film are illustrated in Fig. 6. The absorption maxima are: yellow, 440 mμ, magenta, 540 mμ and Cyan, 675 mμ.

Sensitivity and Resolving Power: The color negative film has an exposure index of 16. The resolving power, as measured by the method proposed by Sayce,[4] is 44–48 lines/mm.

Ansco Color Duplicating Negative Film, Type 846

Film Characteristics: The Color Dupe Negative Film is similar to the Color Negative Film Type 843 in layer arrangement and color absorption characteristics. However, the color sensitivity is

different from that of Type 843, but it is similar to that of the Color Positive Film Type 848, as shown in Fig. 9. In order to produce dupe negatives with fine grain and good resolution, the emulsions used for this film type are much slower. The exposure index is approximately 0.6 to 1.0. This film type is also on gray base of the density of the Negative Type 843 so that it can be readily interspliced with it. The resolving power is approximately 66 lines/mm. The sensitometric characteristics of the color dupe negative film are shown in Fig. 7.

The color dupe negative film is used to make color negative dupes from tricolor separation positives made from the color negative originals. Optical effects, fades, lap dissolves and other special effects can be introduced via these color dupe negatives. The various methods which can be used to obtain a color positive release print will be described later, below.

Ansco Color Positive Release Printing Film, Type 848

Film Characteristics: In emulsion layer arrangement the color positive release printing film is similar to the color negative film shown in Fig. 1. The color positive film can be exposed either directly from color negative originals, from color negative dupes or from black-and-white tricolor separation negatives. The sensitometric curves of the individual layers of the color positive film, plotted as integral densities, are shown in Fig. 8. In Fig. 9 the spectral sensitivity of the color positive printing film is illustrated. Good separation of the spectral sensitivity ranges with a minimum of overlaps is desirable for good color reproduction in the printing film.

Dye Absorption: The absorption characteristics of the dyes produced in the color positive film are different from those in the color negative and dupe negative film. The absorption maxima are: 440 mμ for the yellow layer, 540 mμ for the magenta layer, and 660 mμ for the cyan layer.

Film Speed and Resolving Power: The sensitivity of the color positive film is similar to black-and-white positive, approximately exposure index 1.5. The resolving power is 64–66 lines/mm.

All three color film types used in the Ansco Color Negative-Positive Process are on low-shrink, safety base.

Color Processing Procedures and Solutions

The three color film types used in the process require very similar processing steps and processing solutions. Only the Color Negative Film, Type 843, requires a different color developing solution. The color dupe negative film and the color positive release printing film can be developed in the same solutions throughout. The color developing time of these two types is different, as shown in Table I.

For uniform processing of all types of color film materials good control of the processing solutions at all times is very important. Basic control procedures which apply also to the handling of color negative-positive have been described by Bates and Runyan,[5] while analytical procedures to control and maintain solution strength and uniformity have been presented by Brunner, Means and Zappert.[6] General information in regard to color sensitometry may be found in the report of the SMPTE Color Sensitometry Subcommittee.[7]

Methods of Release Printing From Ansco Color Negatives

Methods of release printing from Ansco color negatives for the printing of Ansco color negative originals from different methods and certain variations thereof can be used to produce color positive release prints. These methods are summarized in Fig. 10.

Not all of these methods are equal in regard to color quality and cost. A more detailed discussion of the ad-

Table I. Processing Steps and Materials for the Three Color-Film Types Used in the Ansco Color Negative-Positive Process.

	Neg. Type 843, min	Neg. Dupe Type 846, min	Pos. Type 848, min
Alkaline pre-bath*	—	—	2
Jet rinse	—	—	30 sec
Color developer (608)	10–12	6–7	—
Color developer (609)	—	—	11–14
Rinse (859B)	30 sec	30 sec	30 sec
Hardening fixer (804)	8	8	8
Wash	4	4	4
Bleach (715A)	6	6	6
Wash	4	4	4
Fixer (800)	8	8	—
Wash	6	6	—
Dry	25	25	—

* The alkaline pre-bath prepares the alkali-soluble antihalo layer for removal by the jet rinse.

Air squeegeeing and edge treatment of sound track (silver track)	30 sec
Wash	2 min
Final fix (800)	4 min
Wash	8 min
Stabilizing bath	2 min
Rinse	1 sec
Dry	25 min

Processing Formulas

Ansco Color Negative Developer 608

Water (60–70 F)	900 ml
Hexametaphosphate (Calgon or Nullapon BFC)	1 g
Sodium sulfite (Na_2SO_3)	3 g
Ansco S-5 Color Developing Agent	7 g
Sodium carbonate ($Na_2CO_3 \cdot H_2O$)	75 g
Sodium sulfate (anhydrous)	30 g
Potassium bromide (KBr)	2 g
Ansco DA-1 Accelerator Solution (5%)	5 ml
Potassium iodide (KI)	3 mg
Water to	1 l

(Developing time for 843, 10–12 min at 68 F)

#122A Replenisher for Ansco Color Developer #608

Water (60–70 F)	750 ml
Hexametaphosphate (Calgon or Nullapon BFC)	1 g
Sodium sulfite (Na_2SO_3)	3.75 g
Ansco S-5 Color Developer Salt	11 g
Sodium carbonate ($Na_2CO_3 \cdot H_2O$)	75 g
Sodium sulfate (anhydrous)	30 g
Potassium bromide (KBr)	1 g
Ansco DA-1 Accelerator Solution	6 ml
Sodium hydroxide (NaOH) approx.*	2 g
Water to	1 l

* The hydroxide content is adjusted to obtain a pH 0.45 higher than that of a fresh mix of 608 Developer.

(A representative replenishment rate is 11 l/1000 ft of 35mm Color Negative Type 843.)

Ansco Color Developer 609

Water (60–70 F)	900 ml
Hexametaphosphate or Nullapon BFC	1 g
Sodium sulfite (Na_2SO_3)	2 g
Ansco S-5 Color Developing Agent	5 g
Sodium carbonate ($Na_2CO_3 \cdot H_2O$)	60 g
Potassium bromide (KBr)	1 g
Potassium iodide	1 mg
Water to	1 l

Normal pH approx. 10.5, as determined with Beckman Model G pH meter with long-range electrode type 42 or equivalent.

Developing time for 846, 6–7 min at 68 F.
Developing time for 848, 11–14 min at 68 F.

Continued on the following page.

Table I—Concluded.

#106C Replenisher for Ansco Color Developer #609

Water (60–70 F)	750 ml
Hexametaphosphate	1 g
Sodium sulfite (Na_2SO_3)	3 g
Ansco S-5 Color Developer Salt	7.5 g
Sodium carbonate ($Na_2CO_3 \cdot H_2O$)	60 g
Sodium hydroxide (NaOH) approx.*	2 g
Water to	1 l

* The hydroxide content is adjusted to obtain a pH 0.4 higher than fresh mix of #609 developer.

A representative replenishing rate is 11 1/1000 ft of 35mm Color Negative Type 843.

Rinse (859B)

Acetic acid (glacial)	3 ml
Sodium acetate (anhydrous)	30 g
Water to	1 l

pH fresh *about* 5.4

Replenisher (858)

Acetic acid (glacial)	10 ml
Sodium acetate (anhydrous)	20 g
Water to	1 l

Replenish continuous to maintain pH 5.4 to 5.8.

Hardening Fixer (804)

Water	750 ml
Chrome alum [$KCr(SO_4)_2 \cdot 12H_2O$]	30 g
White alum [$KAl(SO_4)_2 \cdot 12H_2O$]	20 g
Sodium acetate (anhydrous)	10 g
Sodium sulfite (anhydrous)	10 g
Hypo ($Na_2S_2O_3 \cdot 5H_2O$)	200 g
Water to	1 l

pH = 4.0

Bleach (715A)

Water	750 ml
Hexametaphosphate	1/2 g
Potassium ferricyanide	100 g
Sodium acetate (anhydrous)	40 g
Acetic acid (glacial)	2.25 ml*
Water to	1 l

* Vary to adjust to pH 4.5–4.7.

Fixer (800)

Water	750 ml
Sodium thiosulfate ($Na_2S_2O_3 \cdot 5H_2O$)	200 g
Water to	1 l

Stabilizer

2% solution of formaldehyde

Sound Track Developer

Solution A

DA-5	1 g
Metol	20 g
Sodium sulfite (anhydrous)	40 g
Hydroquinone	20 g
Sodium thiosulfate	3 g
Formalin (37%)	20 ml
Water to	1 l

Solution B

Thickener (Cellosize) Stock Solution

Hydroxyethyl cellulose (WP40)	45 g
Water to make	1 l

For use: Add 100 ml of Solution B to 900 ml Solution A and add 200 cc of Thickener Stock Solution.

vantages and disadvantages of each of these methods is, therefore, in order.

Method A. Printing From Original Color Negatives Interspliced With Opticals on Color Dupe Negatives

This method, shown schematically in Fig. 11, comes closest to present black-and-white practices, at least as far as domestic releases are concerned. The color negative originals, which may represent 60–75% of the total footage, are interspliced with optical effects such as fades, lap dissolves, etc., made on Color Dupe Negative Film Type 846 Tricolor separations on Fine Grain Duplicating Pan Film are made from the full-length negative. They are used as protection masters. The optical effects are produced from sections of

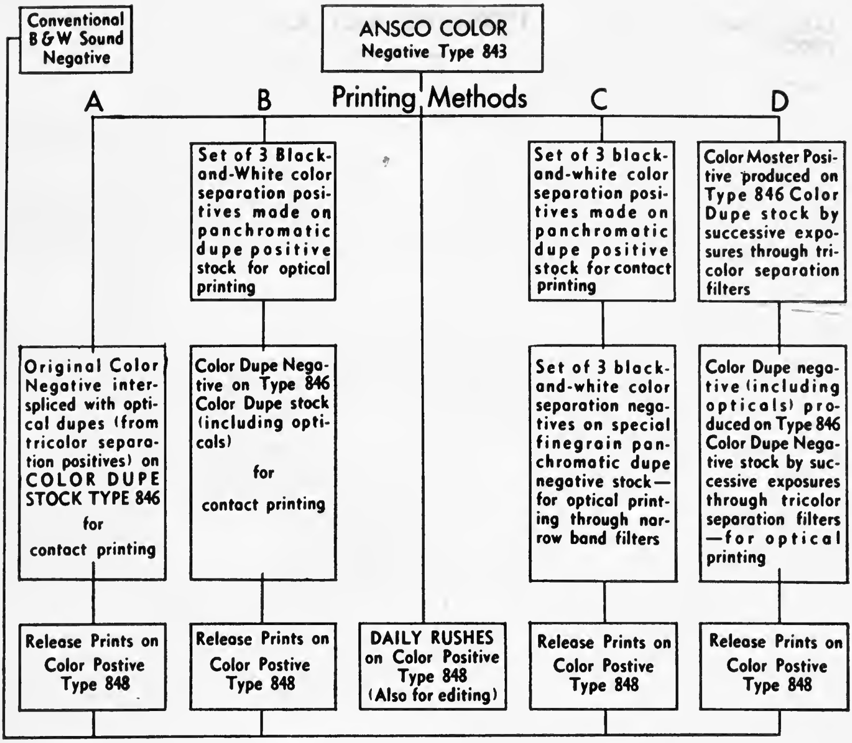


Fig. 10. Summary of methods which can be used for release printing.

these black-and-white separations by printing on Color Dupe Negative Film Type 846. Method A, which involves a minimum of color printing by the use of color negative originals except for opticals and effect shots, leads to the best color quality. This method would be first choice for domestic releases.

Method B. Printing From Full-Length Master Dupe Negatives

In Method B, as shown in Fig. 12, release printing is done from master color dupe negatives. This method is recommended where the original color negatives cannot be made available for release printing. This is frequently the case for foreign releases. Tricolor separations on panchromatic duplicating film are made from the cut negative. Master color dupe negatives on Type 846 are made from all scenes, including opticals and special effects. Scene-to-scene conformance can be attempted in making the separations, as well as in printing the master dupe negatives, so that only minor color balance and light corrections have to be made during the release printing steps. The black-and-white separations also serve as protection masters.

As in Method A, the release printing is done by contact printing. In both methods conventional equipment, such as a Model D or Model E Bell & Howell or similar printers, can be used.

The filters required to correct for the overall and scene-to-scene color balance variations in printing are determined by the use of a color scene tester similar to the one described by F. P. Herrnfeld.[8]

On the Model D printer provisions

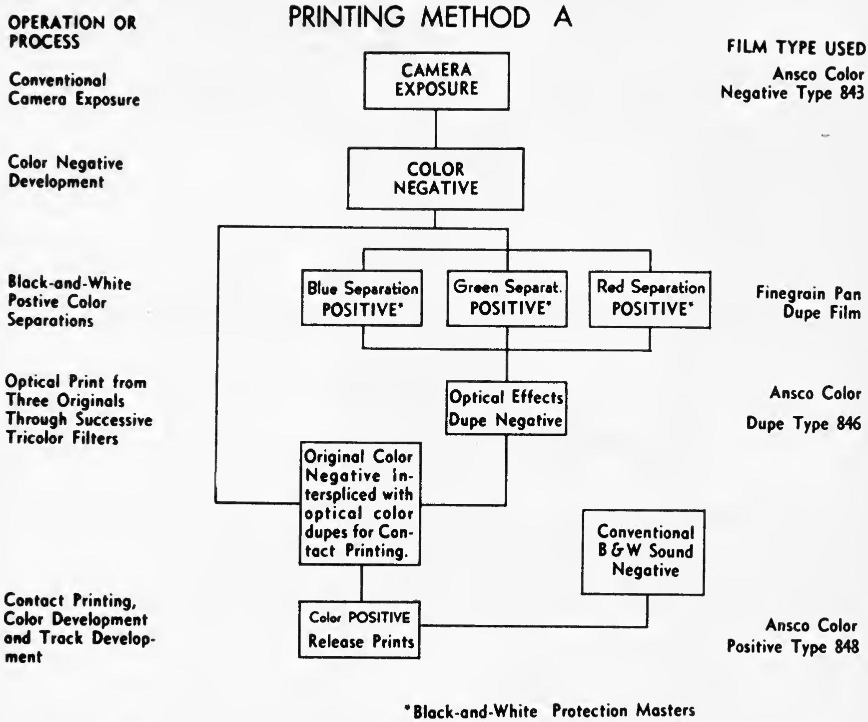


Fig. 11. Method A: Printing from original color negatives interspliced with opticals on color dupe negatives.

should be available for the insertion of color balance filters.[8] Following a suggestion made by the Metro-Goldwyn-Mayer Laboratory, a special material for colored traveling mattes for the Model E Bell & Howell printer has been made available. Film base dyed uniformly to produce various color filter combinations, coated with positive finegrain emulsion, is exposed and processed by the Laboratory to produce a "variable width" type light control strip in the center of the film, as shown in Fig. 13.

Appropriate lengths of different colored matte negatives, representing the various light and color balance changes are spliced together. This colored traveling matte automatically corrects for scene-to-scene variations in color balance and density and the full speed of the printer can be utilized.

In the preparation of master color dupe negatives on Type 846 film, the following sensitometric conditions are representative:

Negative-Positive Duplication Control Gammas

	B	*G*	*R*
Color Negative Type 843	1.15	1.00	1.00
Separations*	0.75	0.75	0.75
Color Dupe Negative Type 846	1.20	1.10	1.10
Color Positive Release Print Type 848 . .	3.00	2.70	2.70

Sensitometric test strips exposed with a light source approximately 3200 K, using an intensity scale sensitometer and measured on a Macbeth-Ansco Model 12 Color Densitometer.

* Black-and-white separations exposed on an Eastman Type IIb Sensitometer and measured on Western Electric RA-1100B Densitometer.

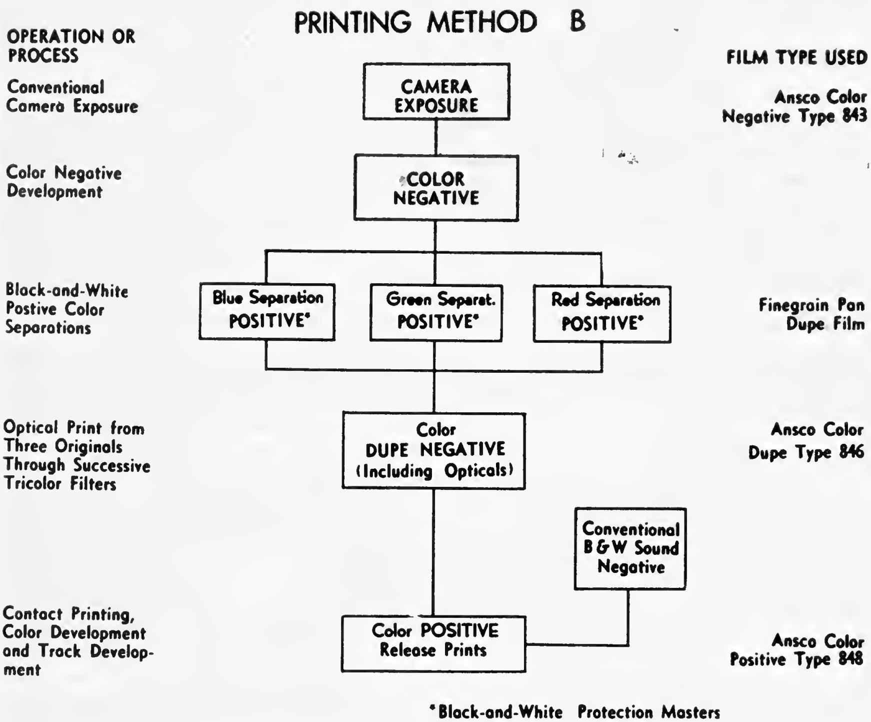


Fig. 12. Method B: Printing from full-length master dupe negatives.

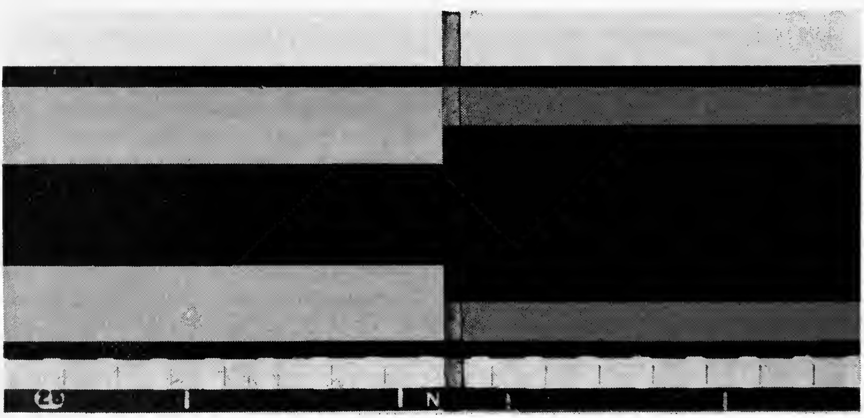


Fig. 13. Traveling matte for light and color balance control on Model E-type printer. Film on the left side of the splice is color correction filter density CC10Y. Film on right side is CC filter density 15M+0.05Y.

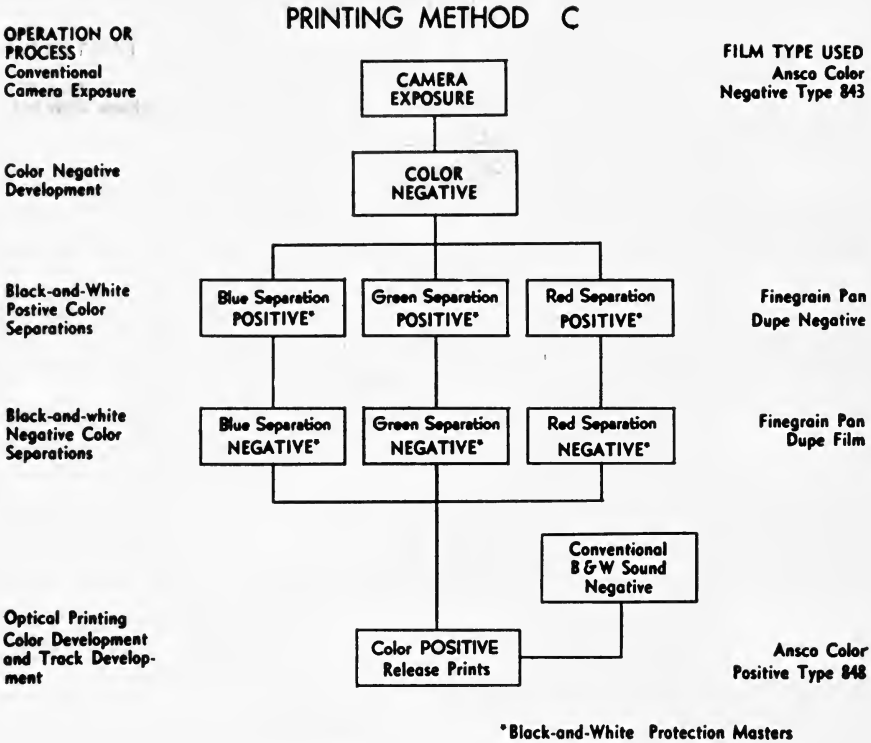


Fig. 14. Method C: Release printing from black-and-white separation negatives.

The method described next requires optical printing and is shown schematically in Fig. 14.

Method C. Release Printing From Black-and-White Separation Negatives

In Method C three-color separation positives on fine-grain Pan Duplicating Film are made from the color negative originals. These positives are printed on the same fine-grain duplicating film, this time developed to a lower gamma negative. Optical effects can be introduced during this printing step. The black-and-white three-separation negatives, including the optical effects, are used for release printing on Ansco Color Positive Film Type 848, preferably using multihead printers with good registration.

Method C avoids one color printing step as compared with Method B, and if very carefully controlled allows somewhat higher color brilliance. However, due to the fact that optical printers have to be used, the release printing is considerably slower and the method requires great accuracy in sensitometric and registration control, and for that reason is not generally recommended. A fourth method not requiring tricolor separations should also be mentioned. Although the color degradation produced by this printing Method D is definitely noticeable, results have been better than expected. This method is briefly outlined in Fig. 15.

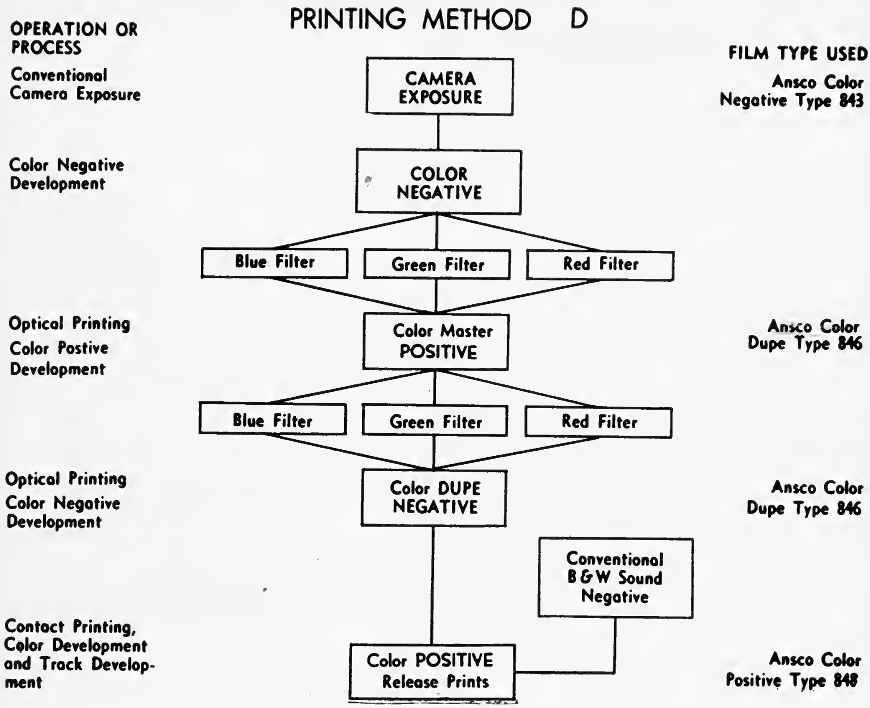


Fig. 15. Method D: Release printing from color dupe negatives via color dupe positives.

Method D. Release Printing From Color Dupe Negatives via Color Dupe Positives

In Method D color positive prints on Color Dupe Film Type 846 are made from the original color negatives using sharp cutting filters. The filters recommended are Ansco UV-16 for all printing steps in addition to the three-color separation filters:

Wratten Filter No. 70;
Wratten 16 plus Wratten 61; and
Wratten 23 plus Wratten 48A.

These filters are also recommended for making the three-color separations in Methods A, B and C.

The Color Dupe Film Type 846 is developed as a color positive. Optical effects can be introduced at this step or the next one, in which the color positive dupe is again printed on Color Dupe Stock 846 with the same sharp cutting filters. This time the 846 Film is developed as a low-contrast color negative. The contrast of this dupe negative should be kept as closely as possible to the same contrast as the original color negative. This second generation color dupe negative can be used for release printing on a conventional contact printer. The Method D does not provide for black-and-white protection masters. For this reason this method is not recommended for feature pictures. A description of this method has been included because there may be occasions where this procedure may offer certain advantages; also, the fact that color rendition is still quite acceptable is a good indication of the flexibility of the Ansco Color Negative-Positive Process.

Sound on Ansco Color Release Printing Film Type 848

The reproduction of sound from multilayer color films using developed dye images has for some time presented a problem, especially in connection with the red sensitive photocell, which is today the standard for 35mm motion picture projection.[9] In order to obtain a track which is efficient in absorption in the infrared region of the 868-type phototube, a method to produce a combination silver-plus-dye track having response characteristics similar to the conventional black-and-white silver tracks has been worked out.

Sound Track Development

As shown in Table I, the Color Positive Release Printing Film Type 848, after color development, fixing, bleaching and washing, is surface-dried by effective air squeegeeing. At this stage the sound track area carries a sound image consisting of a dye image from the original color developing step plus a silver ferrocyanide image, produced in the silver bleaching step. Using an applicator wheel or a pen-type applicator, a high viscosity rapid developer solution is applied to the sound track area only. This developer reduces the silver ferrocyanide-plus-dye sound image to a metallic silver + dye image. For the selective treatment of the sound track area, the following steps are important.

1. Effective air squeegeeing to remove surface moisture. The air squeegee should be close to the applicator station to prevent diffusion of moisture to the surface of the emulsion before developer solution is applied in the form of a bead covering the sound area only.
2. Application of high viscosity sound track developer, treating time approximately 30 sec.
3. To accelerate the development of silver track, infrared heat lamps at this stage are advantageous.

Cross-modulation and listening tests have indicated that variable-area sound negatives used for printing Color Positive 848 should have about the same densities as used for printing on black-and-white positive fine-grain film. Densities between 2.40 and 2.70, as read on a Western Electric RA-1100 Densitometer, are satisfactory. Sound printing with filtered light to confine the sound image to the two top layers is preferable. The top layer alone may be used for variable-area tracks.

The variable-area silver-plus-dye track of the edge-treated color positive film shows very good cancellation, fully equal to black-and-white tracks. The contribution of, and the effect of the dye image underlying the silver track image is insignificant in terms of the 868-type phototube response. A yellowish stain in the track area reduces the volume only by about 2 db.

Experience with variable-density recording is still somewhat limited, although satisfactory recordings have been made. In order to produce satisfactory gradation and resolution characteristics, the sound track should be confined to the two top layers, with equal contributions by both layers.

Acknowledgments

The development work reported in this paper represents the combined efforts of many people of the Ansco Research and Development Dept., as well as the Ansco technical staff in Hollywood. The valuable assistance of the Metro-Goldwyn-Mayer Laboratory, in particular J. M. Nickolaus, J. Arnold and D. Shearer, in cooperating on the various phases of the process and in supplying sample negatives and dupes for this presentation, is gratefully acknowledged.

References

1. H. H. Duerr and H. C. Harsh, "Ansco Color for professional motion pictures," *Jour. SMPE*, *46:* 357–367, May 1946.

2. F. Wing, "Ansco Color Film," *Ansconian*, 3–11, Sept.–Oct. 1943. J. L. Forrest, "Machine processing of 16mm Ansco Color Film," *Jour. SMPE*, *45:* 313–326, Nov. 1945.
3. W. Schneider, A. Fröhlich and H. Schultze, "Die diffusionsfesten Farbbildner des Agfacolor Films," *Chemie*, *57:* 113–116 (DEZ.) 1944.
4. L. A. Sayce, *Photographic Journal*, *80:* 454, 1940.
5. J. E. Bates and I. V. Runyan, "Processing control procedures for Ansco Color Film," *Jour. SMPE*, *53:* 3–24, July 1949.
6. A. H. Brunner, Jr., P. B. Means, Jr., and R. H. Zappert, "Analysis of developers and bleach for Ansco Color Film," *Jour. SMPE*, *53:* 25–35, July 1949.
7. A Report of the Color Sensitometry Subcommittee, "Principles of color sensitometry," *Jour. SMPTE*, *54:* 653–724, June 1950. (Reprinted as a booklet.)
8. F. P. Herrnfeld, "Printing equipment for Ansco Color Film," *Jour. SMPTE* *54:* 454–463, Apr. 1950.
9. R. Görisch and P. Görlich, "Reproduction of color film sound records," *Jour. SMPE*, *43:* 206–213, Sept. 1944.
   A. M. Glover and A. R. Moore, "Phototube for dye image sound track," *Jour. SMPE*, *46:* 379–386, May 1946.
   R. O. Drew and S. W. Johnson, "Preliminary sound recording tests with variable-area dye tracks," *Jour. SMPE*, *46:* 387–404, May 1946.
   A. B. Jennings, W. A. Stanton and J. P. Weiss, "Synthetic color-forming binders for photographic emulsions," *Jour. SMPTE*, *55:* 455–476, Nov. 1950.
   J. L. Forrest, "Metallic-salt track on Ansco 16mm Color Film," *Jour. SMPE*, *53:* 40–49, July 1949.

Discussion

J. G. Frayne: Dr. Duerr mentioned a variable density track density of 0.85. This would be high for unmodulated density and would yield low level output. Do you propose using variable density tracks that are that dark?

H. H. Duerr: The density of 0.85 obtainable in the top layer alone referred to, is the maximum density. The unmodulated, unbiased operating density would, of course, be considerably lower and closely related to regular black-and-white practice. The best median density has to be established by further tests.

Dr. Frayne: Does this density figure 0.85, include the base?

Dr. Duerr: No. This is the maximum density obtainable in the top layer.

C. R. Daily: Do you intend to produce a tungsten-type film for use with a color temperature of approximately 3350 K?

Dr. Duerr: We are now producing only a film for daylight-type illumination, but expect to have a tungsten-type film available later on. Whether it will be balanced for 3350 K or a somewhat lower color temperature is not yet certain.

Frank E. Carlson: You referred to a color temperature of 5400 K for the negative film. Is the film balanced to the spectral emission of a black body radiator at that color temperature?

Dr. Duerr: Yes.

Richard H. Ranger: I have no question, but would like to compliment Dr. Duerr on his presentation, because the work shown here tonight represents great strides over the results demonstrated to a group of engineers in Wolfen shortly following the end of hostilities in Germany several years ago.

Multiple-Image Silhouette Photography for the NOTS Aeroballistics Laboratory

By ERNEST C. BARKOFSKY

A technique of multiple-image silhouette photography has been developed for the NOTS Aeroballistics Laboratory. Six or more silhouette images of missile models are imposed at a high rate upon a single photographic plate. A series of such plates is used in precision photogrammetry to determine the orientation and position of the models in transonic and supersonic flight. While neither stroboscopic nor silhouette photography is unique in itself, it is believed that the combination of the two, as described in this paper, is a new technique.

A TECHNIQUE of multiple-image silhouette photography has been developed by the Ballistics Division, Research Department, of the U. S. Naval Ordnance Test Station, Inyokern, for utilization in the NOTS Aeroballistics Laboratory. This technique is used in precision photogrammetry to determine the position and orientation of missile models in transonic and supersonic flight through the Laboratory. In order to obtain the desired accuracy in the aerodynamic and ballistic coefficients of the missile models, it is necessary that the mean deviation of a number of comparator measurements on the photographic images does not exceed a few ten-thousandths of an inch. It was found that this accuracy in measurement could be attained only by photographing the models in silhouette with microsecond-duration light flashes.

Considerations of economy and efficiency, however, demanded that a minimum of six silhouette images be recorded (at rates up to 3000/sec) on a single photographic plate; and experimental development of this technique has resulted in multiple-image silhouette photography of the desired quality.

The NOTS Aeroballistics Laboratory

The NOTS Aeroballistics Laboratory is a high-precision, enclosed range; an exterior view of the Laboratory is shown in Fig. 1. Inert missile models will be launched from a 3-in. gun and will pass through the 500-ft-long range building. The missiles will be photographed at 4-ft intervals during their flight, with photographic coverage provided by 23 pairs of precision ballistics cameras positioned so that the fields of view of

Presented on October 16, 1951, at the Society's Convention at Hollywood, by Ernest C. Barkofsky, Ballistics Div., U.S. Naval Ordnance Test Station, Inyokern, China Lake, Calif.

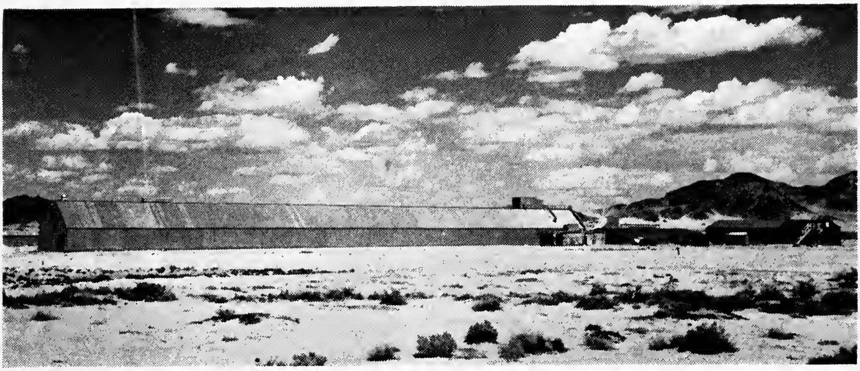


Fig. 1. The NOTS Aeroballistics Laboratory; Gun Platform and Control Room at right; Missile Stop at left.

adjacent cameras are overlapping. This relationship of the cameras is shown in Fig. 2. Each camera will photograph the missile six times, so that each photographic plate will bear six images for assessment. Figure 3 is a cross-sectional schematic drawing of the Aeroballistics Laboratory, and shows the orientation of the pair of cameras at each of the 23 Stations of the Laboratory. Figure 4 is a down-range view. Associated with each camera is a bank of three electrical-discharge flash lamps, the sources of microsecond-duration illumination of the missile models in transonic and supersonic flight. Much instrumentation was required to make possible the high-speed, multiple-image silhouette photography.

Instrumentation

The desired accuracy in the determination of the variation of position and orientation with time of the missile models to be studied in the Aeroballistics Laboratory imposed severe specifications in the performance requirements of the necessary instrumentation. In particular, detailed consideration had to be given to the many factors contributing to the errors of the photogrammetry: camera and lens; camera survey; photographic technique, including emulsion, developer and development combination; geometry of the camera-rocket model array; and exposure time and timing. An ultra-precision ballistics camera was designed and developed; a high-quality, wide-angle lens was selected for the camera; and a catenary system was designed to permit the calibration of the camera plates. A new photographic technique, that of multiple-image silhouette photography, was developed. The production of microsecond-duration flash illumination, precisely timed, required a complex electronic and electrical system including: (1) a photoelectric triggering system which provides for the start of the flash lamp illumination by the passage of the missile model through a light screen; (2) an electronic "gate" which stops the lamp flashing at each station after the rocket has passed from the field of view of the camera; (3) a light-flash counting system; (4) a master electronic timing system; (5) an electronic monitoring system: (6) a high-voltage power source; and (7) an electronic system for simulating the transonic and supersonic flight of a missile model through the Laboratory.

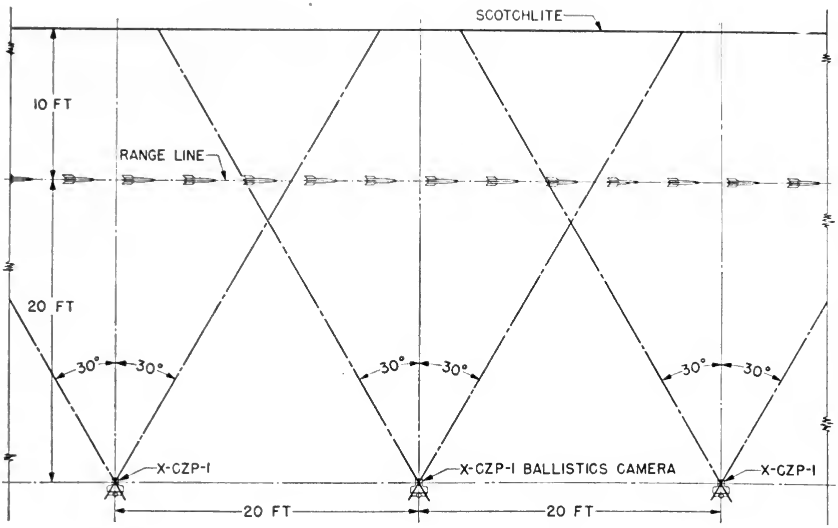


Fig. 2. 45° longitudinal schematic presentation of the NOTS Aeroballistics Laboratory.

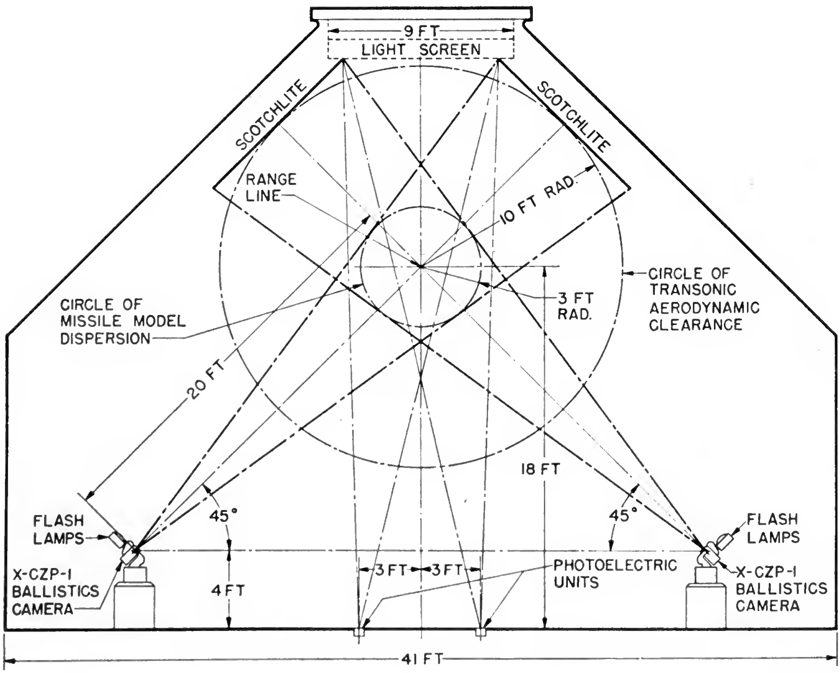


Fig. 3. Transverse schematic presentation of the NOTS Aeroballistics Laboratory.

Multiple-Image Silhouette Photography

The technique of multiple-image silhouette photography was developed expressly for use in the NOTS Aeroballistics Laboratory. Since the location of the transverse components of the center of gravity of the rocket model must be determined to within 0.001 ft, and since the magnification of the ballistics camera is 1/39th, measurements on the photographic plate must be made to within less than 0.0003 in. Because of the other factors which contribute to the error in the position determination, the accuracy of the comparator measurements on the photographic image may be only a fraction of the 0.0003 in. ($= 7.5\ \mu$). The accuracy of measurement possible with the best of comparators is of the order of one micron, hence the quality of the photographic image must be such that it in itself introduces practically no error. The characteristics of a photographic image which make possible precise comparator measurements upon it are sharply defined edges and proper contrast between the image of the object and the background against which it is photographed. It required but very little experimentation to reveal the fact that only by silhouette photography could satisfactory photographs be obtained of the highly polished missile models.

The photography of the missile models in silhouette at each four feet of their travel through the Aeroballistics Labora-

Fig. 4. Down-range view of the interior of the NOTS Aeroballistics Laboratory.

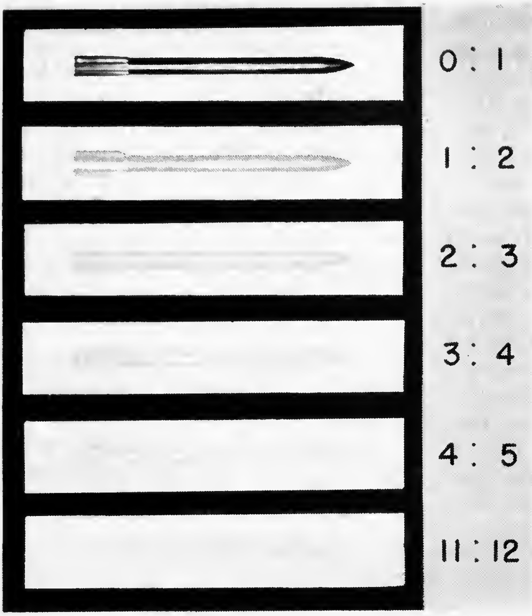


Fig. 5. Preliminary multiple-flash silhouette photographs, showing decrease in contrast with increase in number of superimposed flashes.

tory would have been impossible because of the instrumentation cost involved, if only one silhouette image on each photographic plate were possible. Investigation was therefore made of the feasibility of obtaining more than a single silhouette image on each plate. A serious difficulty with such a procedure is evident: each of N silhouette images on a single photographic plate will have $N - 1$ flash exposures of the bright background superimposed upon it, a condition that may result in very little or even no contrast between the silhouette images and the background. Exploratory work revealed, however, that even with an appreciable number of silhouette images on a single plate, discernable and even measurable images could be obtained. Figure 5 shows a series of photographs of a static model obtained with ever-increasing amounts of light superimposed upon the silhouette image. Measurements made by an inexperienced comparator operator upon one of the first of such a series of test exposures had the following values for the standard deviation of measurement for ten readings on each image:

Ratio of Silhouette Image Illumination to Background Illumination

	0:1	1:2	3:4	9:10
Std. deviation, μ	8.6	3.3	6.9	9.2

An interesting fact revealed by these preliminary measurements is that a true silhouette image (a negative with an opaque background and a transparent image) is less amenable to accurate measurement than an image with less contrast to the background. On the other hand, it is also evident that as the contrast is further decreased, accurate measurement again becomes difficult.

The decrease in contrast with increase in the number of superimposed light flashes is shown by manipulation of the simple equation of the straight-line portion of the photographic characteristic curve:

$$D = \gamma\,(\text{Log } E - \text{Log } i).$$

If $E = \mathcal{N} F$,
where $\mathcal{N}$ = Number of flashes
and F = Energy per flash,
then

$$D = \gamma\,(\text{Log } \mathcal{N} F - \text{Log } i)$$

$$\Delta D = D_{\mathcal{N}} - D_{\mathcal{N}-1} = \gamma \text{ Log } \frac{\mathcal{N}}{\mathcal{N}-1} \propto \frac{1}{\mathcal{N}-1} \quad \text{(within } 10\% \text{ for } \mathcal{N} = 6).$$

This equation shows that the difference in density between a multiple-flash silhouette image and its background decreases as the total number of flashes is increased. Despite this predicted decrease in density difference, the technique of multiple-image silhouette photography has been developed to the degree that six-image photographs can

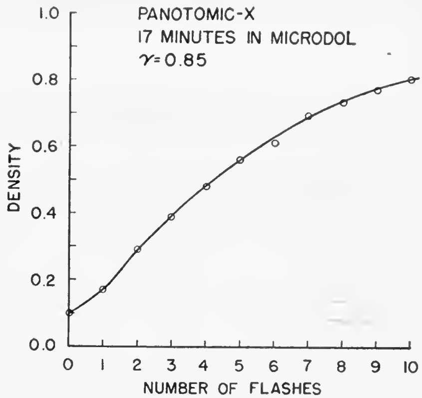


Fig. 6. Characteristic curve of emulsion-developer combination for multiple-image silhouette photography.

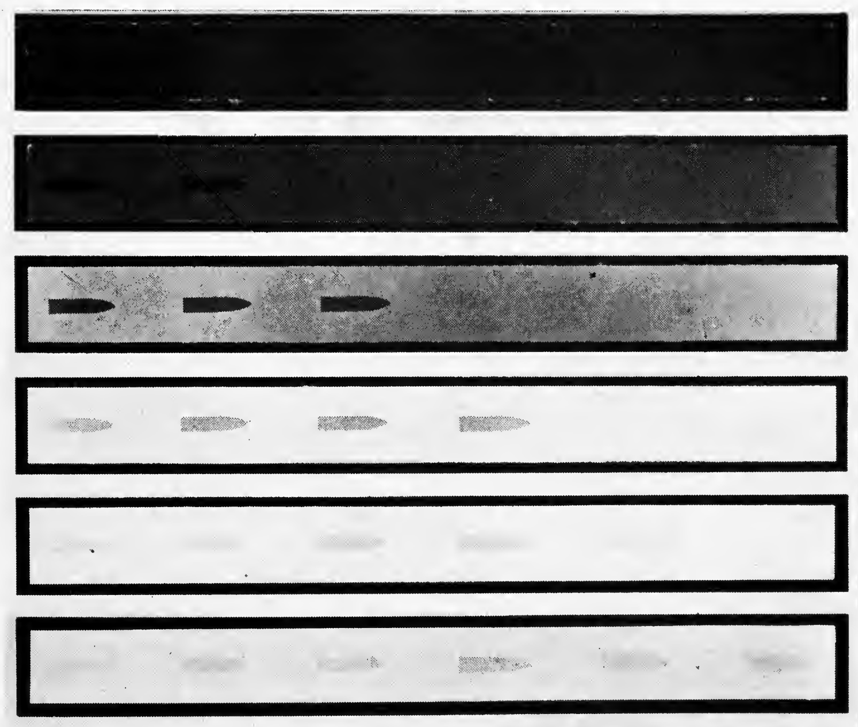


Fig. 7. Flash-by-flash development of six-image silhouette photograph in the NOTS Aeroballistics Laboratory.

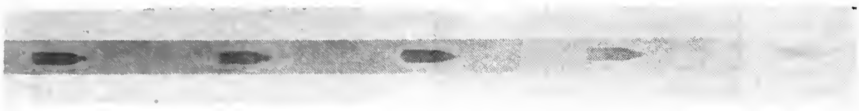


Fig. 8. Five-image silhouette photograph of 20-mm projectiound. at 2800 ft/sec, flash rate of 2000/sec; Scotchlite backgrle in flight

be assessed with an accuracy of only a few microns.

This photography is done with Panatomic-X emulsion developed for 17 min in Microdol. Figure 6 is the characteristic curve obtained for this emulsion-developer combination under the conditions of flash photography in the Aeroballistics Laboratory.

Insufficient density was obtained with the use of flat-white paint or even movie screen as the silhouette background at the distance of 30 ft from the flash lamps, dictated by the geometry of the Aeroballistics Laboratory. It was found that No. 30 Wide-Angle Silver Scotchlite sheeting was very satisfactory for use as the silhouette background in the Aeroballistics Laboratory. By the use of Scotchlite, sufficient intensity was obtained with the superposition of six flashes on a single plate to yield negatives of satisfactory density. Figure 7 shows the flash-by-flash development of a six-image silhouette photograph.

Figure 8 is a high-speed, five-image, silhouette photograph of a 20-mm projectile in flight at 2800 fps. This photograph is representative of those to be obtained in the NOTS Aeroballistics Laboratory.

Summary

The technique of multiple-image silhouette photography, when employed in conjunction with the instrumentation of the Aeroballistics Laboratory, permits the accurate determination of the aerodynamic and ballistic characteristics of missile models. The information concerning the performance of the models can be extrapolated for utilization in the design and development of improved missiles.

Optical Problems in High-Speed Camera Design

By JOHN C. KUDAR

CONCERNING THE optical theory of the rotating prism in high-speed cameras, there have been Letters to the Editor published in the *Journal* in July 1951. As the Letters dealt with more or less controversial interpretations of the problems involved in conventional high-speed camera design, I am glad to have this opportunity to expand upon the applications of the basic principles to the definite possibility of a promising and perhaps unexpected development in this field. It is necessary, however, to start with a survey of the existing commercial types.

The rotating polygonal prism as an optical component, such as a cube or an octagonal prism, is the generalized case of the rotating plane-parallel plate. One well-known high-speed camera is based on this principle of the plane-parallel plate. The image projected through the rotating plane-parallel plate moves with the same speed as the continuously traveling film, at least during the short exposure time. Another well-known camera differs in its optical construction in that the plane-parallel plate is replaced by a rotating cube or by an octagonal prism. In all cases the exposure is limited to small incidence angles by blacking edge pieces which act as shutters during the rotation.

The precise thickness of the plane-parallel plate (or polygonal prism) must be designed in accordance with the refractive index, as well as in consideration of the maximum incidence angle allowed for exposure. The correct mathematical formula for the thickness was well known long before the design of the first high-speed camera, since the principle of the rotating prism projector came up at the very beginning of motion picture films.

The two types of cameras discussed have a common feature in their mechanical design, which is that the film transport at the place of exposure is geared to the prism rotation. The development of high-speed cameras depended essentially on improvements in mechanical manufacturing and design, while the problem of optical precision was concerned only with suitable limitations for the incidence angles and with the precise thickness of the plate or prism.

The refractive index of the glass material can be shown to be without any notable influence on the quality of image formation by the rotating prism. Even the dispersion is irrelevant, due to the deliberate limitation of the incidence angle during exposure. As the Letters to the Editor in the July 1951 *Journal*

Presented on October 16, 1951, at the Society's Convention at Hollywood, by John C. Kudar, 1809⅜ Las Palmas Ave., Hollywood 28, Calif.

deal with these controversies in detail, there is no need to go into this aspect of the optical theory of the rotating prism.

As the choice of glass material for the prism is left free from the point of view of optical design, the final decision can be made on the basis of other considerations. With regard to the choice of the glass material, the centrifugal stress in the rotating prism is worth careful consideration. For the same angular velocity, the centrifugal force acting on the peripheral volume element is proportional to the product of the thickness of the prism and the specific gravity. The thickness of the prism must be designed proportional to:

$$\frac{n}{n - 1}, \tag{1}$$

if n is the refractive index. Then the centrifugal force is proportional to:

$$\frac{n}{n - 1} \cdot S, \tag{2}$$

if S is the specific gravity. For low-index glass, we may assume an ordinary crown glass with $n = 1.5$ and $S = 2.5$. A representative high-index glass may be a rare-earth glass with $n = 1.8$ and $S = 4.6$. Consequently, the product (2) is 7.5 for low-index glass, and 10.35 for high-index glass. This shows that the centrifugal force on the periphery of the high-index prism is, instead of being smaller, nearly 40% greater than on the periphery of the low-index prism.

The optical and mechanical principles underlying the construction of commercial high-speed cameras with rotating prism or plate have been known for half a century. The task of exploring the possibly hidden potentialities of the polygonal prism method, beyond the scope of conventional constructions, has long been overdue. With respect to the necessary high rate of rotation, it is of particular interest to investigate whether the mechanical properties could be essentially simplified by introducing some unconventional optical means. It would be desirable, without doubt, to avoid any gearing between prism rotation and film movement at the place of exposure. The precise position of the film relative to the prism facet could be maintained much better with a single rotating unit, serving the double purpose of mechanical and optical movement. Such a single rotating unit should incorporate the rotating prism into a film sprocket. In the conventional case, however, this is not possible, as the correctly designed polygonal prism is always larger than the corresponding sprocket, supposing equal number of frames and facets. Neglecting minor design corrections, the thickness of the prism, i.e., the distance D between opposite parallel facets, is:

$$D = \frac{HNn}{2\pi(n - 1)} \tag{3}$$

in which H is the full frame height, i.e., the film length per frame; N is the number of facets; and n is the refractive index. In comparison, the diameter of the corresponding film sprocket must not be larger than:

$$\frac{HN}{\pi}. \tag{4}$$

These two formulas show that the polygonal prism could be reduced to or below the periphery of the film sprocket, but only under the condition that the refractive index is not less than 2. That means that all commercial high-index glass is useless for this purpose.

In order to arrive at a practical solution involving a single rotating unit at the place of exposure, we must abandon the idea of the solid prism as a conventional unit, which was found to require a refractive index higher than 2, if the prism has to fit within the sprocket periphery. The new polygonal prism has a composite structure. It consists of rotating and stationary components. Its rotating peripheral part is polygonal on the outside and cylindrically hollow inside. The periphery of the polygon fits into the periphery of a corresponding sprocket.

The stationary components form a separate unit, which fills the cylindrical cavity inside of the rotating polygonal ring, without obstructing the rotation. The film is guided around part of the periphery by sprocket teeth, where the exposure takes place. The curvature of the film on the periphery of the rotating component is compatible with the optical system.

The purpose of this device is to get rid of the conventional gearing in the central part of the camera, where the exposure takes place. The feed and take-up parts can remain similar to those already in use. The making of hollow polygonal prisms with twelve or more facets does not represent great manufacturing difficulties. Their use in high-speed cameras will have the advantage that for the same film speed the rate of rotation (and the centrifugal force) is slowed down in proportion to the increase of the number of facets.

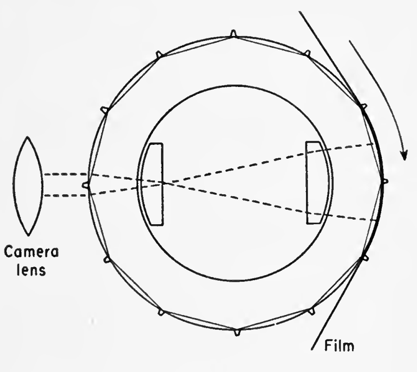


Figure 1.

Many different designs are possible, based on the principle of the composite polygonal prism. The simplest possible optical construction (Fig. 1) is shown diagrammatically in cross section through the rotation axis of the polygon, and parallel to the optical axis. In the cylindrical cavity of the rotating polygonal prism two plane-convex cylindrical lenses are placed in stationary position. The plane-parallel air gap between the flat faces of the cylindrical lenses increases the image displacement by refraction, as illustrated by two parallel rays coming from the camera lens and refracted several times. The diagram represents an air thickness between the flat sides of the two cylindrical lenses approximately equal to the total glass thickness of the composite polygonal prism, in which case the refractive index of the glass (for the polygon and the cylindrical lenses) must be about 1.6. The narrow cylindrical air menisci between the rotating polygonal component and the cylindrical lenses can be designed for zero power. (In a similar model, actually built for 35mm film, the zero power air menisci have been made 0.5 mm thick.)

It should be noted that in conventional high-speed cameras a substantial distance is kept between the film and the prism, while in the case of the new device the film under exposure is perhaps very close to the prism facets. Therefore, black shutter strips on the edges of the new polygonal prism should not be used, as they would limit the field vertically. But the required shutter effect can be achieved by suitable vertical limitations on the internal surfaces of the composite optical device.

Some important users of high-speed cameras have a particular interest in highest possible speeds. For such a purpose, it is certainly desirable to have a single rotating unit, and no gearing, in the central part of the camera.

It is in the common interest of the users and manufacturers of high-speed cameras to show clearly the inherent potentialities of the polygonal prism principle. A related development in another field is already going on. It is to be hoped that the inadequate theoretical approach, which has prevailed in this country for the last few years, will not prove a permanent obstacle in this particular field of high-speed photography.

Discussion

John H. Waddell: (an abstract of the remarks which preceded the projection of the Institute of Medical Research high-speed motion picture) Fastax prism design has been studied extensively and there are, of course, constant improvements being made in the cameras as they exist today. When one realizes that the cameras have been developed without benefit of Government sponsorship, but entirely privately, the advances which have been made have been noteworthy.

The photographic quality of the rotating prisms can be observed in the pictures which are going to be projected which were taken at the Institute of Medical Research by Dr. Myron Prinzmetal and his associates. It will be seen that the day of the rotating prism camera is not over.

Centrifugal force as discussed previously has been misinterpreted. We have never seen a prism itself explode. Failure of the prism housing has occurred however, and, in our design problems, the housing has to be constructed so that it does not fly apart when using at ultra high speeds. It is interesting to note that the camera as constructed today will take over twenty g's, and that picture taking rates far in excess of advertised rates have been successfully achieved.

Effective Sum of Multiple Echoes in Television

By A. D. FOWLER and H. N. CHRISTOPHER

Observers compared the interfering effect of multiple echoes with that of single echoes in black-and-white television pictures. The multiple echoes were 2, 4 or 8 echoes of equal strength but different delays. The single echoes were 40, 35 or 30 db weaker than the main signal. A method for estimating addition effects of several echoes is presented and demonstrated to be consistent with the test results.

This paper reports the results of tests comparing the interfering effect of multiple echoes with that of single echoes in black-and-white television pictures. The present study supplements an earlier one in which the interfering effect of single echoes was considered.[1] Although general in application, the test results have a special bearing on the design of television transmission systems, where echo requirements are rather severe and sometimes difficult to meet.

In the tests to be described, observers viewed a standard black-and-white television picture on which was superimposed, for ready comparison, either a single echo or multiple echoes. The single echo was fixed in level (a little above threshold) during a given test; the multiple echoes were then uniformly adjusted in level until they were judged to have the same interfering effect as the single echo. The multiple echoes comprised 2, 4 or 8 echoes of equal strength, and each was assigned a delay in the range of 3 to 14 μsec. The spacings, or delay differences, were uniform in a few tests and random in most.

Over 100 comparison tests, each employing eight or more observers, were made. This rather large number of tests was necessary in order to explore the effects of such things as number of echoes, levels of reference echo, weightings of echoes, spacings between echoes, poling of echoes, and types of picture material.

The results of these tests yielded an empirical relation by means of which the effective sum of multiple echoes can be estimated with reasonable precision. This relation depends upon: (a) weighted echo power; (b) number of echoes; and (c) average spacing between echoes.

Presented on April 21, 1952, at the Society's Convention at Chicago, Ill., by A. D. Fowler and H. N. Christopher, Bell Telephone Laboratories, Murray Hill, N.J.

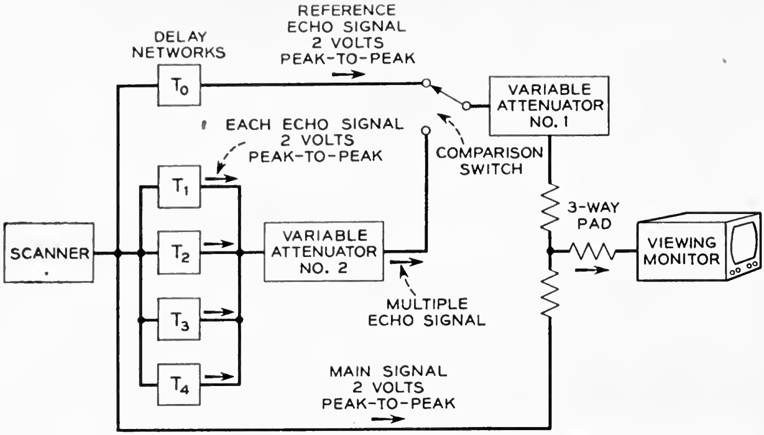


Fig. 1. Simplified schematic of test setup.

Apparatus and Circuit Arrangement

The circuit arrangement for the tests is shown schematically in Fig. 1. In this diagram, various buffing and mixing amplifiers have been omitted in the interests of simplicity. It should be understood, however, that each branch of the circuit was properly isolated and that each echo signal, apart from the indicated delay, was essentially a replica of the main signal.

Referring to Fig. 1, it will be seen that the output of the scanner, which derives composite picture signal from a slide or film, provides three signals: (a) main picture signal; (b) single reference echo signal, delayed T_0 microseconds; and (c) multiple-echo signal, comprising 2, 4 or 8 component signals (four are shown for illustration), each delayed T_1, T_2, etc., microseconds, respectively. The main signal is fed to the viewing monitor via a three-way mixing pad where echo signals are introduced. A comparison switch, operated by the observer at will, selects either single reference echo or multiple echo for transmission via attenuator No. 1 to the mixing pad. The multiple-echo path includes attenuator No. 2, by means of which an adjustable loss may be added to that path as required.

Most of the apparatus was laboratory constructed and conventional. The viewing monitor was equipped with a 10-in., black-faced, metal-backed kinescope operated at about 11 kv. The overall transmission, which otherwise would have extended somewhat higher, was limited to 4.3 mc by a phase-equalized low-pass filter.

Picture Material

Most of the tests were made with a slide called *Model White Hat.* This picture shows a close-up of a girl modeling a large white hat against a plain and rather dark gray background. It was known from previous experience that this picture was very sensitive to single echoes which were delayed by more than two microseconds.

Other slides, although known to be less sensitive to single echoes, were used in the tests. These were used because it was suspected that they might exhibit unusually severe addition effects of multiple echoes.

A motion picture film of *Model White Hat* was employed in one test. This was used to see if motion, itself, caused some of the cloudlike multiple echoes to be more readily noticed.

Procedure

A picture from the scanner was established on the viewing monitor with the proper highlight luminance and contrast ratio. Reference echo was then set at a fixed level (40, 35 or 30 db weaker than main signal) by adjustment of attenuator No. 1. The observer was then asked to view the picture with reference echo present and, upon switching alternately from reference to multiple echoes, to declare whether multiple echoes had less or more interfering effect. The experimenter would then adjust attenuator No. 2 appropriately to make the interfering effects more nearly equal. When the interfering effects were judged to be equal, the values of the attenuators were recorded, No. 1 registering the level of reference echo, and No. 2, the relative interfering effect of the multiple echoes. The test was repeated for each of the other observers.

Viewing was done in a darkened room and from a distance of four times the picture height. In two of the tests, the viewing distance was changed to $13\frac{1}{3}$ times the picture height.

As a check on the results obtained by the comparison method described above, a Comment Test was made. The general procedure for this kind of test has already been reported in some detail.[2,3] A series of intermixed conditions, viz., single and multiple echoes at various levels of each, were displayed in a randomized sequence. Ten experienced observers rated each condition by choosing one of seven preworded comments listed for the purpose.

It was apparent that the relative interfering effect of single echoes of different delays would play an important part in the results. Accordingly, a comparison test was made using single echoes of various delays in the path shown in Fig. 1 for multiple echoes. The reference echo was delayed 7 μsec and was set at a level of 40 db below main signal. The same procedure and viewing conditions were employed as in the multiple-echo tests.

Summary of Results

The results of each test, together with the conditions under which the test was made, are shown in Table I. The essential test results are tabulated under the heading *Relative Interfering Effect (db)* in columns labeled *Meas.* (measured) for the appropriate level of reference echo. Entries in those columns are the average values of the settings of attenuator No. 2 for the number of observers listed. Entries in the columns labeled *Calc.* are corresponding calculated values to be discussed below.

In summarizing the results of the tests, it will be convenient to employ the terms *effective echo power*, *weighted echo power* and *advantage.* These terms are defined as follows:

Effective echo power, expressed in db above the physical power of a single reference echo, denotes the relative interfering effect as determined by subjective tests. In db, its value is given numerically by the loss in attenuator No. 2, as determined by judgments.

Weighted echo power, also expressed in db above the physical power of reference echo, is the sum of the weighted physical powers of the component echo signals. The weightings are time (delay) weightings of single echoes referred to that of the reference echo.

Advantage is the ratio, expressed in db, of *weighted echo power* to *effective echo power.* When effective echo power is less than weighted echo power, a positive advantage (over power addition) obtains; when the addition effects are more severe than power addition, a negative advantage obtains.

The principal result of these tests may be summarized in an approximate rule for estimating effective echo power of multiple echoes:

$$\textit{effective echo power (db)} = \textit{weighted echo power (db)} - \textit{advantage (db)}.$$

Table I. Test Conditions and Results.

Picture: *Model White Hat;* highlight, 42 ft-L; contrast ratio, 100:1; 24-in. (4 × H) viewing distance, unless noted otherwise.

No of echoes	Delay of each echo, μsec	Ref. echo delay μsec	Avg. spacing, μsec	Wt.'d echo pwr., db	Relative interfering effect at 3 levels of ref. echo: 40 db Meas.	40 db Calc.	35 db Meas.	35 db Calc.	30 db Meas.	30 db Calc.	No. of observers	Remarks
1	½	7			−13.8						11	
1	1	7			−7.7						11	
1	2	7			−4.9						11	Data for weighting of single echoes
1	4	7			−3.6						11	
1	7	7			0.0						11	
1	10	7			+0.6						11	
1	13¾	7			+1.2						11	
2	11 11	11	0	3.0	6.3	6.0					10	
2	11 11¼	11	¼	3.0	5.6	5.0					10	
2	10¾ 11¼	11	½	3.0	4.8	4.3					10	
2	10¾ 11½	11	¾	3.0	4.1	3.6					10	
2	10½ 11½	11	1	3.0	3.1	3.0					10	
2	10 11½	11	1½	3.0	2.1	2.1					10	
2	10 12	11	2	3.0	2.4	1.5					10	
2	10½ 11½	11½		3.0	3.5	3.0					10	
2	10 12	11½	2	3.0	1.5	1.5					10	
2	9 13	11½	4	3.0	0.6	0.4					10	
2	8¼ 13¾	11½	5½	2.8	1.6	0.1					10	
2	10½ 11½	11½	1	3.0	3.2	3.0	4.1	3.2	4.2	3.7	10	
2	10 12	11½	2	3.0	1.4	1.5	2.2	1.8	3.2	2.7	10	
2	9 13	11½	4	3.0	0.7	0.4	2.2	1.0	2.8	2.1	10	
2	8¼ 13¾	11½	5½	2.8	0.2	0.1	1.5	0.7	2.6	1.9	10	
2	10 12	11	2	3.0	1.7	1.5	2.1	1.8	2.7	2.7	8	
2	4 4½	7	½	−0.3			0.4	1.0			8	
2	5 7	7	2	2.1			0.2	0.9			8	

4					8	10	12	14	11	2.0	5.8	3.5	2.8	3.2	3.5	4.2	5.2	10	
4					6	9¼	11¾	13¾	8¼	2.6	6.2	2.2	2.1	3.5	3.1	4.7	5.0	10	
4	3	3¾	4¼	5½					8¼	0.8	2.6	3.0	3.5	4.2	3.8	4.6	4.6	10	
4	3	3½	4	4½					7	0.5	2.3			2.8	5.0			8	
4					5	7	12	13¾	7	2.9	6.3			3.4	3.0			8	
4			4½	5		7	12		7	2.5	5.4			1.5	2.4			8	
4	3		8			10½		13¾	8¼	3.6	5.6	0.5	0.6	2.1	1.8	3.7	4.0	10	
4	3		8			10½		13¾	8¼	3.6	5.6	0.8		2.2		3.4		10	Comment test: critical (90%) observer
												1.2		2.6		3.6			median (50%) observer
8	6	8	9	10	11	12	13	14	10	1.1	8.9	9.1	8.3	8.5	8.9	8.5	10.5	10	
8	6	8	9	10	11	12	13	14	10	1.1	8.9	8.1	8.3	7.8	8.9	8.2	10.5	10	
8	3	5¾	8	8¼	9¾	10½	11½	13¾	8¼	1.5	8.8	5.7	6.1	6.8	7.0	7.7	9.1	23	
8	3	5¾	8	8¼	9¾	10½	11½	13¾	8¼	1.5	8.8	5.6	6.1	7.7	7.0	8.8	9.1	12	Motion picture
8	3	5¾	8	8¼*	9¾	10½*	11½*	13¾	8¼	1.5	8.8	4.6	6.1	6.4	7.0	8.0	9.1	11	*Negative poling
8	3	3¾	4¼	5½	6	9¼	11¾	13¾	8¼	1.5	7.7	3.0	5.0	4.5	5.9	5.2	8.0	10	
8	3	3¼	5¼	6¾	7¼	10	13½	13¾	9¼	1.5	7.8	4.5	5.1	6.2	6.0	6.0	8.1	3	
8	3	3½	4	4½	5	7	12	13¾	7	1.5	7.7			3.8	5.9			8	
8	6	9¼	9½	10½	11¾	12½	13¼	13¾	9½	1.1	9.0	9.8	8.4	10.1	9.0	10.5	10.6	10	
4					11	12	13	14	12	1.0	6.0	8.3		9.0		9.5		3	80-in. viewing distance
4					8	10	12	14	11	2.0	5.8	5.2		4.1		4.1		11	80-in. viewing distance
Picture: *Teacup Lady;* highlight, 42 ft-L; contrast ratio, 100:1; 24-in. viewing distance																			
												35 db		30 db		25 db			
8	6	8	9	10	11	12	13	14	10	1.1	8.9	11.2		12.0		12.3		3	
Picture: *Model in Patio;* highlight, 42 ft-L; contrast ratio, 100:1; 24-in. viewing distance																			
												35 db		30 db		25 db			
8	3	5¾	8	8¼*	9¾	10½*	11½*	13¾	8¼	1.5	8.8	4.0		5.0		6.6		10	*Negative poling
Picture: *Harpist;* highlight, 40 ft-L; contrast ratio, 100:1; 24-in. viewing distance																			
												25 db		20 db		15 db			
8	3	5¾	8	8¼*	9¾	10½*	11½*	13¾	8¼	1.5	8.8	8.4		8.2		8.3		12	*Negative poling

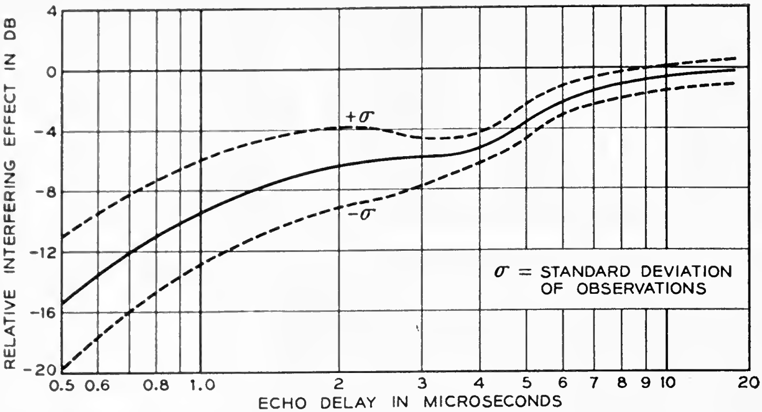


Fig. 2. Relative interfering effect of single echoes for picture *Model White Hat*. Reference echo 40 db below main signal.

Weighted echo power, for the purpose of checking the test results obtained with *Model White Hat*, can be calculated using the weighting curve given in Fig. 2. Advantage, which depends on the number of echoes and the average spacing between echoes, is given approximately by the family of curves (or straight lines) in Fig. 3. The relations shown in Fig. 3 apply when the reference echo is 40 db weaker than the main signal; at higher levels of reference echo, there is progressively less advantage. This will be seen in Figs. 4 and 5, which apply to 35- and 30-db criteria, respectively. The method of determining the empirical advantage curves from the test data is described in Appendix I.

To show how well the test results are reflected in the empirical advantage curves, the latter have been used, together with the time weightings of Fig. 2, to "predict" the test results. A comparison of the measured and computed values of effective echo power, expressed in db, is shown in Fig. 6. On the whole, the correlation is very satisfactory: 75% of the data points fall within ±1 db of the predicted values; 91% fall within ±2 db.

The picture, *Model White Hat*, chosen, as stated above, for its sensitivity to single echoes, proved to be the most sensitive of several pictures to multiple echoes. The results were substantially the same for a motion picture of *Model White Hat* as for the slide taken from the same film and used for most of the tests.

In a few tests the polarity of about half of the echoes was reversed. This produced no significant change in the results.

Increasing the viewing distance results in more severe addition effects. This is more than offset, however, by the accompanying decrease in interfering effect of either single or multiple echoes.

In a single check test, it was found that the "Comment Method" of rating picture impairments gave the same results as the comparison method used in this series of tests.

Discussion of Results

The approximate rule of addition of several echoes, as deduced from the data, is an empirical one with limited applications. It applies to eight echoes, or less, to echoes having individual interfering effects differing by no more than about 6 db, and to echo spacings

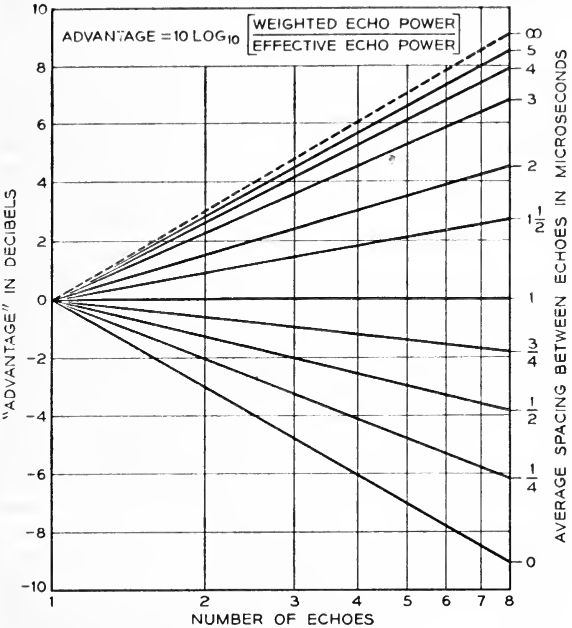


Fig. 3. Advantage vs. number and average spacing of echoes. Reference echo 40 db below main signal.

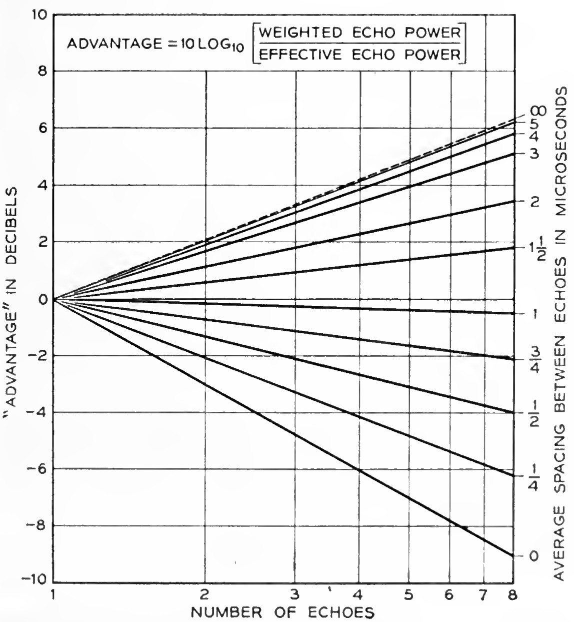


Fig. 4. Advantage vs. number and average spacing of echoes. Reference echo 35 db below main signal.

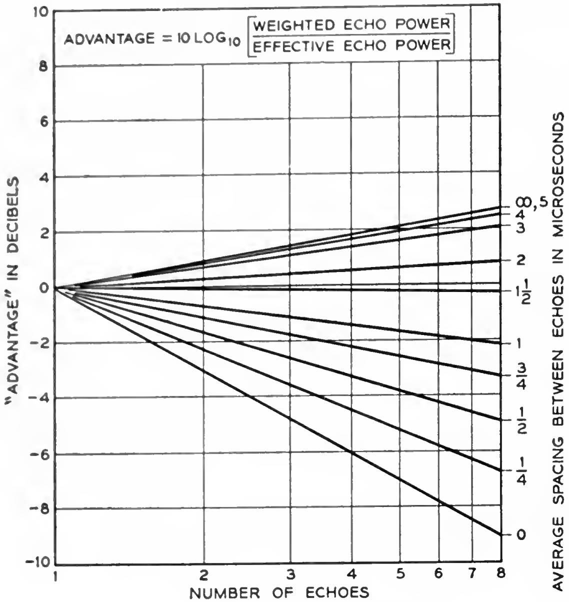


Fig. 5. Advantage vs. number and average spacing of echoes. Reference echo 30 db below main signal.

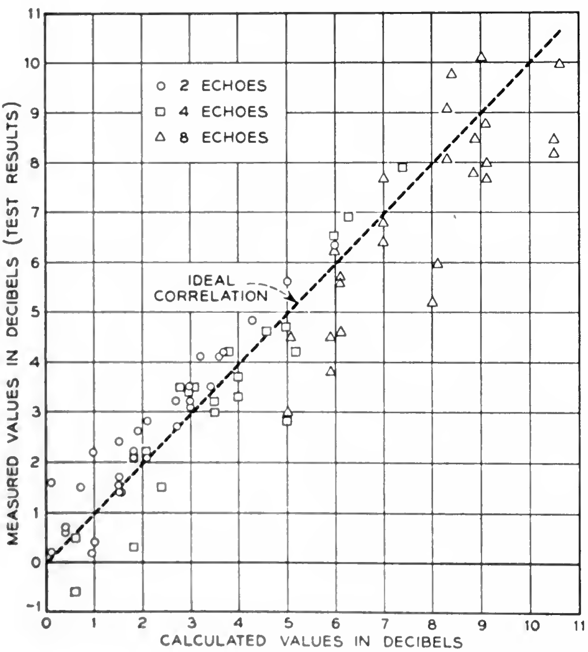


Fig. 6. Correlation of measured and calculated values of relative interfering effect. Combined data for 40, 35 and 30 db criteria.

not excessively* different from the average of those spacings. Although a general *law of addition* of echoes was not discovered, it is not clear that it would be very useful for present purposes. Such a law would probably be either very complicated, if applicable to specific cases, or too general for specific applications, if based on statistical averages.

It is generally conceded that as the number of echoes becomes large, "advantage" should tend to vanish, and the effective power of the many echoes should approach weighted power. (This presupposes a random distribution of amplitudes, polarities and delays, which tend to make the total echo signal like noise.) In this study of echo addition, there was no noticeable trend toward decreasing advantage as the number of echoes was increased (up to eight echoes) unless there was an accompanying decrease in average spacing.

In Fig. 6, showing the correlation of the test results with computed values, the data points are lumped together for the three kinds of tests where the reference echo was 40, 35 and 30 db below the main signal. Although the overall correlation is very satisfactory, a still better correlation is obtained for the 40-db data taken alone. The correlations for the 35-db and 30-db data are progressively worse. This trend is probably related to the greater difficulty observers had in comparing multiple with single echoes as the visibility of the echoes was increased.

APPENDIX I

Determination of Empirical Advantage Curves

Assume several echoes, identical in every respect except amplitude and delay. The peak-to-peak amplitudes are taken as I_1, I_2, I_3, etc., and are expressed in terms of unit amplitudes of a single reference echo. Suppose, for the moment, the delays are all rather large, so that the interfering effects of the several echoes taken singly are about the same. If all the delays are the same, the echoes will fall precisely on one another, and the effective amplitude, I_e, of the sum of the echoes will be, simply:

$$I_e = I_1 + I_2 + \ldots + I_N. \qquad (1)$$

If the delays increase progressively by about 1 μsec, the effective amplitude appears (from the test results) to be expressible as:

$$I_e^2 = I_1^2 + I_2^2 + \ldots + I_N^2. \qquad (2)$$

This suggests a simple rule of addition of the form:

$$I_e^r = I_1^r + I_2^r + \ldots + I_N^r, \qquad (3)$$

where the exponent, r, depends upon the spacing (or delay difference) of successive echoes. Although uniform spacing is assumed, moderate departures from uniformity can be tolerated.

In the tests, the physical amplitudes, I_1, I_2, etc., were equal, but in general had different time-weightings. Let the weighing of the nth echo be w_n db, where positive values of w_n mean greater interfering effect than an equal-amplitude reference echo. The interfering effect of N echoes of unit physical amplitude will exceed that of the reference echo by M db, where M is given implicitly by:

$$10^{\frac{rM}{20}} = \sum_{n=1}^{N} 10^{\frac{rw_n}{20}}, \qquad (4)$$

or explicitly by:

$$M = \frac{20}{r} \log_{10}\left(\sum_{n=1}^{N} 10^{\frac{rw_n}{20}}\right). \qquad (5)$$

The special value of M when $r = 2$, i.e., when power addition obtains, is

* The standard deviation of the spacings should not exceed the mean spacing.

designated M_0. It represents *weighted echo power*, expressed in db above the power of reference echo, and is given by

$$M_0 = 10 \log_{10} \left(\sum_{n=1}^{N} 10^{\frac{w_n}{10}} \right). \qquad (6)$$

When the weightings are small — and they were purposely made so by making the delay of the reference echo about equal to the mean delay of the N echoes — first-order approximations can be used with fair accuracy in computing (5) and (6). Approximately, then,

$$M \doteq \frac{20}{r} \log_{10} N + \frac{1}{N} \sum_{1}^{N} w_n, \qquad (7)$$

and

$$M_0 \doteq 10 \log_{10} N + \frac{1}{N} \sum_{1}^{N} w_n. \qquad (8)$$

The difference, $M_0 - M$, is defined as *advantage* and is designated by A, where

$$A \doteq \left(1 - \frac{2}{r}\right) 10 \log_{10} N. \qquad (9)$$

Note that when $r = 2$, $A = 0$ for power addition; when $r = 1$ (zero spacing between echoes), $A = -10 \log_{10} N$, indicating current (or voltage) addition; and as $r \to \infty$, $A \to +10 \log_{10} N$, indicating no addition effects, i.e., M is determined by the single most effective echo of the group.

The approximate expression, (9), for *advantage*, depending only on spacing (as r does) and number of echoes, N, was used as the basis for processing the data. The test data gave values of M directly; M_0 (relative weighted echo power) was computed using the weighting curve of Fig. 2; subtracting M from M_0 gives *advantage*, A. Dividing A by $10 \log_{10} N$ gives the factor $(1 - 2/r)$. At this point the data are segregated according to criterion, i.e., reference echo at 40, 35 and 30 db below main signal. The factor $(1 - 2/r)$ was then plotted separately for each criterion and, in all cases, against ΔT, the average spacing of echoes. The relations, $(1 - 2/r)$ vs. ΔT could fairly accurately be represented by smooth curves. By choosing ΔT as parameter, and using values of $(1 - 2/r)$ taken from the smooth curves, expression (9) can be plotted in the form shown in Figs. 3, 4 and 5.

In each of the above three figures, one of the *advantage* curves is indicated for $\Delta T = \infty$. These represent the apparent limits of positive *advantage* approached as ΔT is increased somewhat beyond 5 or 6 μsec. The limiting values of *advantage* were derived from the smooth curves of the factor, $(1 - 2/r)$, which appeared to have asymptotic values as ΔT increased.

References

1. P. Mertz, A. D. Fowler and H. N. Christopher, "Quality rating of television images," *Proc. IRE, 38:* 1269–1283, Nov. 1950.
2. A. D. Fowler, "Observer reaction to low-frequency interference in television pictures," *Proc. IRE, 39:* 1332–1336, Oct. 1951.
3. A. D. Fowler, "Observer reaction to video crosstalk," *Jour. SMPTE, 57:* 416–424, Nov. 1951.

The Image Iconoscope—a Camera Tube for Television

By P. SCHAGEN, H. BRUINING and J. C. FRANCKEN

The oldest television camera tube, the iconoscope, is now used only for transmitting still pictures (e.g. the signal picture of a certain station) and film pictures. Further development of camera tubes in Europe has followed a course different from that in America. In the U.S.A. the image orthicon has become predominant, whilst in Europe the image iconoscope is widely used. Of the latter there are British and French versions and also one that has been developed in the Philips Laboratory at Eindhoven (Netherlands). This Philips image iconoscope is described here and compared with other camera tubes.

The object of television is to transmit moving pictures via electrical means. This is achieved by "measuring" in succession the brightness of the very large number of picture elements into which the picture to be transmitted is imagined as being divided. This measuring consists in the conversion of the brightnesses into corresponding fluctuations of an electric current which in some way or other govern the signal transmitted.

However the time available for measuring the brightness of one picture element is very small, actually only 10^{-7} sec. A method can be imagined, whereby the imaged scene is illuminated continuously on a photosensitive plate, while for each picture element in succession in the space of time of 10^{-7} sec a signal is transmitted which corresponds to an illumination that was present during the whole of the time ($\frac{1}{25}$ sec) available per picture. This idea is to be found materialized in all present-day television camera tubes. With this method there is a continuous accumulation of charge during a frame period, and thus these tubes have come to be known as "storage tubes."

The oldest form of storage tube is the iconoscope, designed by Zworykin (1933). In the main this article will be devoted to a modern camera tube named the image iconoscope. Some other types will be mentioned in passing.

Classification of Modern Camera Tubes

In the most important camera tubes of modern design there is a plate ("target" or "mosaic") on which is projected an electrical image consisting of a two-dimensional pattern of electric

Abstract by Pierre Mertz of a paper in *Philips Technical Review, 13:* 119–133, Nov. 1951.

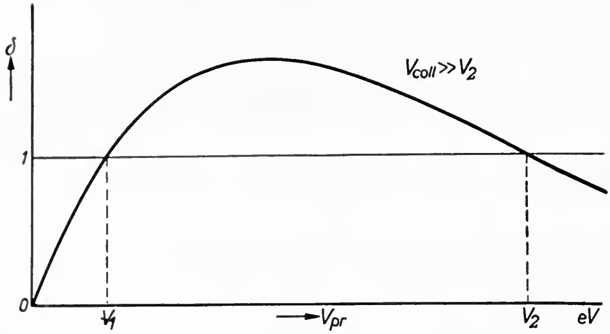


Fig. A. Secondary-emission coefficient δ of an insulator, as a function of the energy V_{pr} of the primary electrons. At two values of V_{pr} (V_1 and V_2) δ is equal to 1. This curve applies when the collector potential is high compared with V_2.

potentials corresponding in amplitude and position to the luminance in the optical image of the scene to be transmitted. This electrical image is scanned point by point by a focused beam of electrons (the scanning beam), the potentials being thereby reduced to a certain "stabilizing potential" which in some way or other produces an electric signal.

The target is, of course, made of an insulating material, e.g. mica. When an electron beam is directed upon it the rule is that for every surface element, in the stable state, on an average just as many electrons have to be emitted as impinge upon it.

When the primary electrons impinge upon a surface element of the plate they release secondary electrons from the material. The secondary-emission coefficient δ, i.e. the average number of secondary electrons released by one primary electron, depends upon the material and the velocity (thus the energy) of the primary electrons at the plate. If V_{coll} is so high that the collector attracts all the secondary electrons towards it, then the variation of δ as a function of the energy V_{pr} (expressed in electron-volts) of the primary electrons is as represented in Fig. A. In the case of most materials there are two values for V_{pr} where $\delta = 1$; the smaller of the two is denoted by V_1, the larger by V_2. For mica, for instance, these material constants are in the order of 10 volts and some thousands of volts, respectively.

Upon reducing V_{coll}, the potential of the surface will be stabilized at a value V_3, where the current intensity of the secondary electrons actually reaching the collector (i_{coll}) is equal to the current intensity i_{pr} of the primary beam. As a rule V_3 is slightly higher than V_{coll} (Fig. B); in contrast with V_1 and V_2, V_3 is therefore not a material constant.

Thus, when bombarded with slow electrons ($V_{pr} < V_1$) the surface potential becomes stabilized at zero, and when bombarded with electrons of high velocity it becomes stabilized at the value V_2 (provided $V_{coll} > V_2$) or at V_3 ($\approx V_{coll} < V_2$). For the target of a camera tube however no use is made of the value V_2, for practical reasons; it is strongly influenced by the condition of the surface and thus is too variable from point to point.

It is according to these possibilities that camera tubes are classified as:

(1) low velocity tubes, where the target is stabilized at cathode potential, and

(2) high velocity tubes, where the target is stabilized at the potential $V_3 \approx V_{coll}$ (e.g. 1000 v).

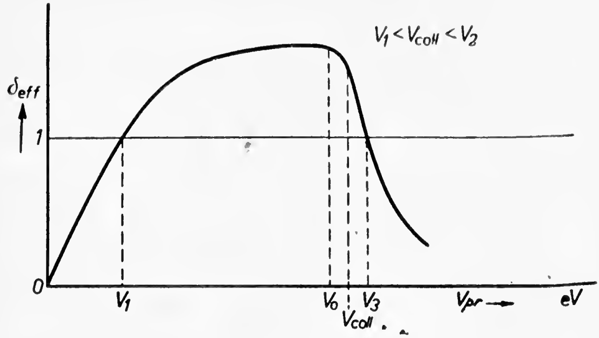


Fig. B. Effective secondary-emission coefficient δ_{eff} of an insulator, as a function of the energy V_{pr} of the primary electrons when the collector potential V_{coll} is smaller than V_2 (cf. Fig. A). $\delta_{eff} = 1$ at $V_{pr} = V_1$ and at $V_{pr} = V_3$, the latter value being a few volts higher than V_{coll}. To the left of V_0 (slightly lower than V_{coll}) the curve is identical to that in Fig. A.

Among the first belongs the image orthicon, which is the type of tube mainly used in the U.S.A., while belonging to the second group are the iconoscope and the image iconoscope, the latter often being given preference in European television circles. One of the reasons for this preference is related to the large number of lines adopted on the West-European continent (625, and in France 819): with a high electron velocity it is easier to satisfy the high requirements for the focusing of the scanning beam which are demanded for the definition required for such a large number of lines.

The Iconoscope

The iconoscope is the camera tube which in its time gave such an impetus to television.[1] It is schematically represented in Fig. C, while in Fig. D a photograph is given of the Philips iconoscope, type 5852.

A lens (objective) projects an image of the scene onto a target of thin mica coated on the front with a mosaic of minute, mutually insulated, photosensitive elements. On the reverse side is a coating of metal, called the signal plate, forming the output electrode and externally connected to earth via a resistor. A ring-shaped coating of metal on the inside of the envelope serves as collector and is connected to earth direct.

The action of the iconoscope is sometimes explained in the following (inadequate) way. The incident light causes the photoelectric elements of the mosaic to emit photoelectrons, which are taken up by the collector. Thus a positive electrical image is formed on the mosaic. The photoelectric elements together with the target form as many minute capacitors. As the scanning beam moves across the mosaic the group of capacitors belonging to a certain picture element are discharged. Through the resistor via which the signal plate is earthed there then flows a small current corresponding in intensity to the charge of the picture element, thus corresponding to the local luminance of the optical picture. Thus in the scanning of the electrical image a series of current impulses are generated which together form the video current.

Actually the position is not so simple as this. Such a description does not take into account the part played by

[1] See, e.g., *Philips Tech. Rev., 1:* 18–19, 1936.

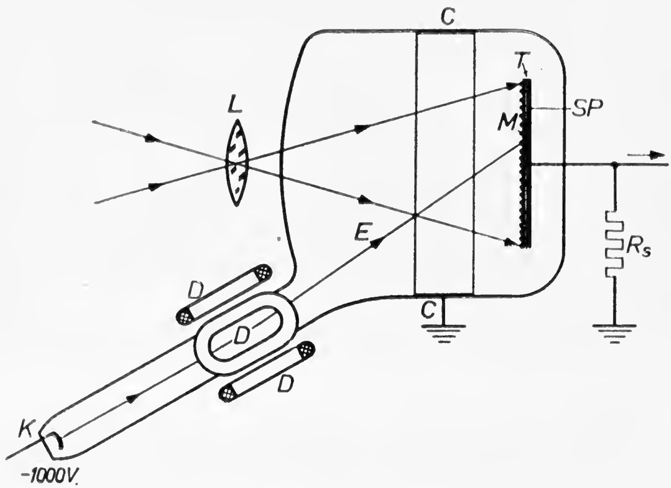


Fig. C. Iconoscope. *L*, a lens projecting the scene on the mosaic *M* of the target *T*. *SP*, signal plate; R_s, load resistor; *C*, collector; *K*, cathode; *D*, deflection coils; *E*, scanning beam. The (electrostatic) focusing is not shown.

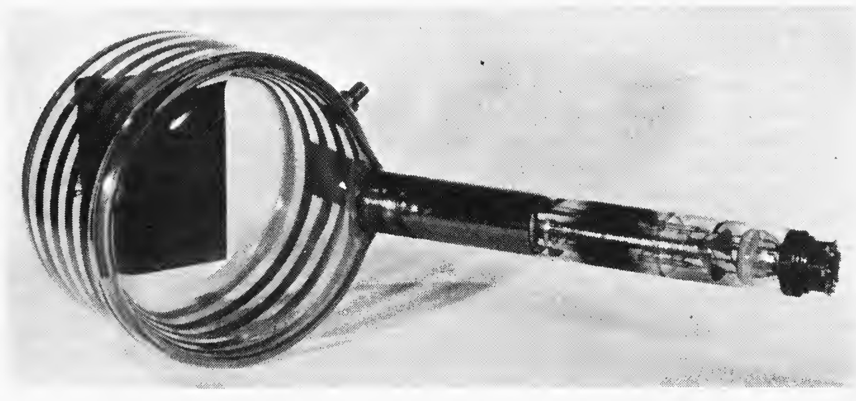


Fig. D. The Philips Iconoscope, Type 5852.

secondary emission.[2] Not all the secondary electrons reach the collector, firstly because the potential of a bombarded surface element is higher than V_{coll}. The secondary electrons which do not reach the collector fall back on other parts of the mosaic. This distribution of the secondary electrons is called the redistribution effect, and it is of essential importance for the action of the iconoscope.

After the surface element in question has been scanned, it will continue to receive secondary electrons originating from other surface elements, until it is scanned by the beam again. Thus its potential *V* begins to drop (Fig. E).

During a considerable part of the

[2] V. K. Zworykin, G. A. Morton and L. F. Flory, *Proc. I.R.E.*, *25:* 1071–1092, 1937; and W. Heimann and K. Wemheuer, Z. *tech. Phys.*, *19:* 451–454, 1938.

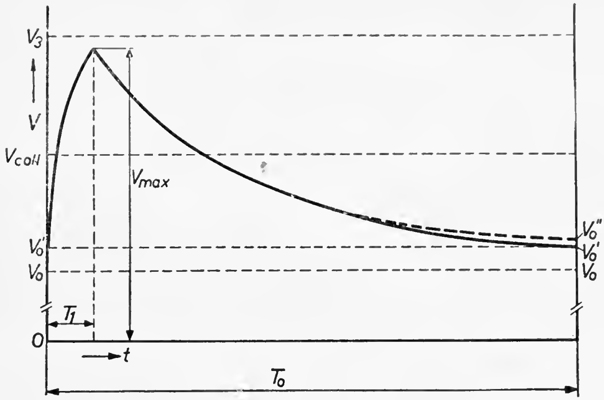


Fig. E. Curve of the potential V of a picture element on the mosaic of an iconoscope, as a function of the time t. Fully drawn line: mosaic not illuminated; broken line: mosaic illuminated. T_0 = scanning period for the whole image (0.04 sec), T_1 = scanning time for one picture element (10^{-7} sec; in the drawing highly exaggerated). For the meaning of V_{coll} and V_3 see Fig. B, and for V_0, V_0', and V_0'' see the text.

scanning period the potential V of the element is higher than V_{coll}, and the photoelectrons do not possess sufficient energy to overcome this potential difference. Photoemission begins, therefore, when — owing to the redistribution effect — the potential V has been sufficiently reduced.

The most important features of the iconoscope will now be briefly discussed.

As already explained, it is due to the redistribution effect that photoemission can take place, but this is only possible during a fraction of a scanning period. Thus we are still far removed from a continuous photoemission such as was imagined in the case of an ideal storage tube! This is one of the reasons for the iconoscope's rather low sensitivity.

A second cause of the lack of sensitivity lies in the mosaic form of the light-sensitive layer. The insulation between the elements does not contribute towards photoemission, so that a considerable part of the surface of the target is photoelectrically inactive.

The main cause of spurious signals (see the literature quoted in footnote [2]) is that the redistribution does not take place in the same way all over the mosaic, owing to the surroundings of the elements not being the same everywhere.

When the iconoscope is illuminated the spurious signal is superposed on the picture signal and only if the latter is of a reasonable strength is the spurious signal not very disturbing. It is for this reason that with the iconoscope very high intensities of illumination are needed.

The stronger the illumination on a certain part of the mosaic, the higher is the potential V_0'' at that spot just before it is scanned by the beam. This has two consequences: there is slightly less chance of further photoelectrons escaping, and there is a somewhat greater attraction of redistributed secondary electrons. Both these effects result in the amplitude of the signal increasing less than proportionately with the illumination. This nonlinearity is rather an advantage than a disadvantage in that it compensates fairly well an inverse nonlinearity between the beam current and the control voltage in the picture tube of the receiver. Thus there is no need to take steps to compensate the latter nonlinear effect.

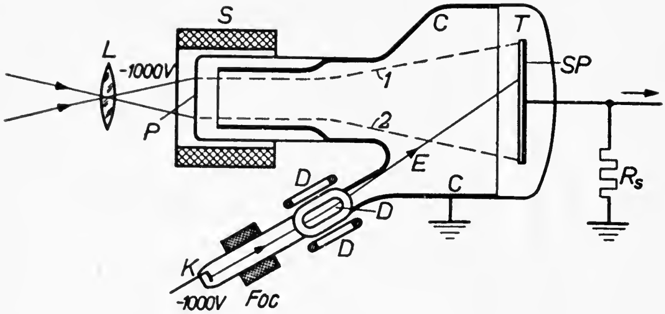


Fig. F. Image iconoscope. *P*, photocathode; *S*, coil of the magnetic electron lens; *1* and *2*, paths of photoelectrons; *FOC*, focusing coil. Other letters have the same meaning as in Fig. C.

Fig. G. The Philips Image Iconoscope, Type 5854.

The Image Iconoscope

The greatest disadvantage of the iconoscope is its lack of sensitivity, and it is for that reason that attempts have been made to develop camera tubes with greater sensitivity, while still retaining the good picture quality obtained with the iconoscope when the scene is sufficiently illuminated.

A year or two prior to 1940 a more sensitive version of the iconoscope, called the image iconoscope, was developed in the U.K. and in the U.S.A.[3] Some improvements on this have since been made in the Philips Laboratory at Eindhoven, as will appear in the course of this article.

In the case of the image iconoscope (Fig. F) a lens (objective) projects an optical image of the scene to be televised onto a continuous, transparent photocathode. The local density of emission of the photoelectrons corresponds to the local luminance of the optical image. This photoemission image is focused by an electron lens onto a target consisting in this case of a thin layer of insulating material applied to the signal plate. The metallized inner wall of the envelope serves as collector. An electron gun mounted in an arm of the envelope supplies the beam of electrons scanning the target.

The differences, compared with the conventional iconoscope, which are mainly responsible for the gain in sensitivity, are the following:

(1) The surface of the photocathode is continuous, so that none of its effective area is lost in insulation between the separate photoelectric elements.

(2) The stream of photoelectrons reaching the target is reinforced by secondary emission, each photoelectron releasing on an average more than two secondary electrons.

(3) The secondary electrons released from the target by the photoelectrons have a much greater energy than the photoelectrons in the ordinary iconoscope, so that secondary emission from a surface element begins immediately after that element has been stabilized by the scanning beam. This means a considerable gain in storage action.

Let us now consider more closely the principal parts of the image iconoscope and also the important question of electron-optical projection. The Philips type of image iconoscope is illustrated in Fig. G.

Contrary to ordinary photoelectric cells, an image iconoscope must have a photocathode which is semitransparent, because the light enters from the outside while the photoelectrons have to emerge on the inside.

The requirements greatly restrict the choice of photoelectric material to be used. The photocathode in the Philips image iconoscope consists of a very thin coating of cesium, antimony and oxygen applied to a flat part of the glass envelope. The sensitivity for the light from an incandescent lamp with color temperature 2600 K is about 45 μa per lumen. The spectral sensitivity curve, compared with the relative luminosity curve for the normal eye, is slightly displaced towards the blue (Fig. H).

The optical image of the scene is converted into a corresponding photoemission image on the photocathode. The next step is to produce on the target an electrical image which is a faithful replica of the photoemission image. This requires that the small beams of photoelectrons emitted from points of the photocathode are focused on corresponding points on the target. For this electron-optical image formation an electron lens is needed.

An electric field has to be employed. This is obtained by means of a metal cylinder (e.g. the metal coating A on the inner wall of a glass tube, Fig. I) facing the photocathode P and applying a potential difference of, say, 1000 v

[3] See, e.g., H. Iams, G. A. Morton and V. K. Zworykin, "The image iconoscope," *Proc. I.R.E.*, *27:* 541–547, 1939.

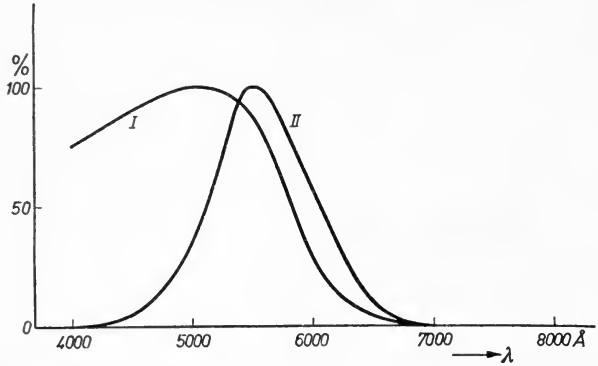


Fig. H. Relative spectral sensitivity of the Type 5854 image iconoscope (curve *I*), compared with the relative luminosity (curve *II*), as functions of the wavelength λ of the light.

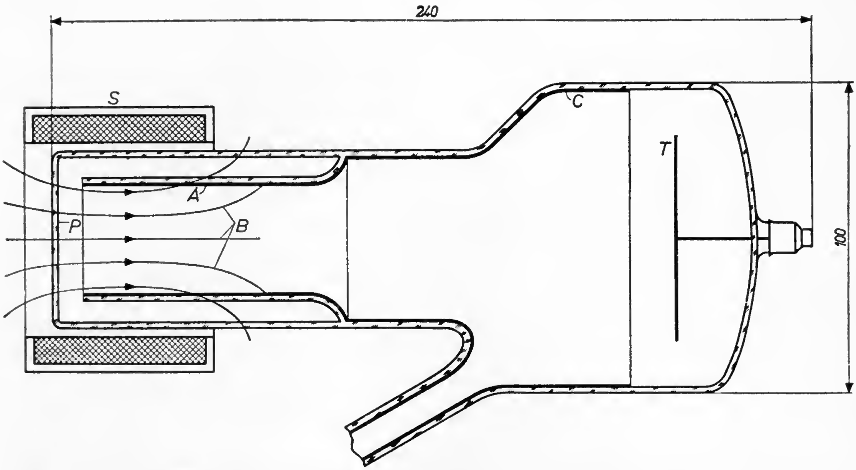


Fig. I. Formation of the electron-optical image of the photocathode *P* on the target *T* with the aid of an electric field (between *P* and the cylinder *A*) and a magnetic field. The latter (lines of flux density *B*) is produced by a focusing coil *S*. Dimensions are in millimeters.

between these electrodes. Since the cylinder forms, electrically, one whole with the earthed collector, the photocathode is given a potential of −1000 v with respect to earth.

This electric field alone, however, does not suffice; a magnetic field has to be added which focuses each electron pencil. Such a field can be produced by means of a coil placed concentrically around the tube. The coil has to be of such dimensions and in such a position as to minimize aberrations, whilst the magnetic field must not disturb the movement of the scanning beam.

The movement of the electrons depends not only upon the two fields mentioned but also upon the velocities of the electrons leaving the photocathode. Some of them have zero initial

velocity, and the paths they follow are called the principal rays. Generally, however, the electrons leave the cathode with a certain velocity, with the result that they follow a more complex path.

Briefly, the course of a principal ray is as follows: at first the path is approximately parallel to the axis of the tube (the z axis), then it diverges farther and farther from that axis, turning about the z axis first clockwise and later counterclockwise in the form of a widening helix.

Although most of the electrons which leave the photocathode have velocities greater than zero and thus do not follow any principal paths, still it is the principal rays which determine the geometry of the electron-optical image. Each forms the axis of a small electron pencil.

The axial component of initial velocity gives rise to a certain "chromatic" aberration: a point of the photocathode from which electrons emerge with axial velocity does not result in a point being formed on the target but a small circle (scattering circle), the diameter of which is so small — thus the image so sharp — that the image iconoscope can quite well be worked with more than 600 scanning lines. In the image orthicon, on the other hand, the electric field at the cathode is ten times smaller,[4] so that with this type of tube the formation of the electron-optical image is a limiting factor for the number of lines.

Owing to the predominance of the diverging forces acting upon the electrons following the principal path the image on the target is magnified, and owing to the tangential forces the electron image is rotated with respect to the optical image on the photocathode, the angle of rotation being about 30 to 40°.

With our image iconoscope the magnification is normally 3.75, which means to say that the scanned part of the target, which always covers an area of 45 mm × 60 mm, corresponds to an area of 12 mm × 16 mm on the photocathode (the diameter of the active part of the photocathode is 20 mm). By exchanging the coil for another of different dimensions it is also possible, however, to work with a larger or a smaller magnification, thus projecting a smaller or a larger part of the photocathode on the target. The choice as regards the size of the effective photocathode is governed by requirements of an optical, light-technical and camera-technical nature. The limits for the magnification are 2.75 and 7.5 (diameter of the projected part of the cathode, respectively, 27 mm and 10 mm).

With a magnification greater than 7 to 8, owing to the "chromatic" aberration of the photoelectrons emerging with axial velocity (see above) there is too great a loss in resolving power.

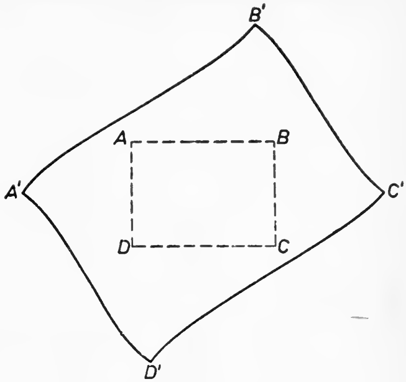


Fig. J. *ABCD* is an image on the photocathode, *A′B′C′D′*, the corresponding electrical image on the target. The latter is magnified and turned with respect to *ABCD* and also shows some S distortion, which always occurs when magnetic lenses are used (straight lines are projected with a slightly S-shaped curve). If the magnification is too small the S distortion becomes so pronounced that it can no longer be sufficiently corrected.

H. B. De Vore, *Proc. I.R.E.*, *36:* 335–345, 1948.

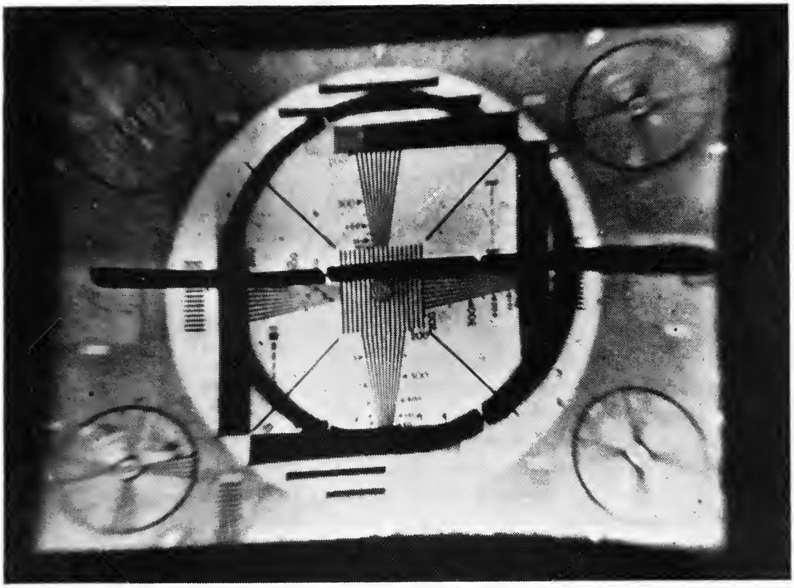


Fig. K(1). Picture showing a marked field curvature, pin-cushion distortion and S distortion. In Fig. K(2), there is only a slight S distortion, which can easily be corrected electrically.

These photographs have been taken with the aid of an experimental tube in which a fluorescent screen was used instead of a target. On the photocathode a test pattern was projected, as used in television, for detecting aberrations and checking the definition and gradation. The heavy black circle and the thick horizontal line in the middle correspond to markings on the photocathode for determining the magnification.

The lower limit of 2.75 is due to various other aberrations, which with a smaller magnification can no longer be sufficiently compensated. As such may be distinguished: field curvature, pincushion distortion and so-called S distortion. The first two are known from light-optics.[5] By S distortion is meant the effect of the image of a straight line being projected as a line curved somewhat in the shape of the letter S (Fig. J). If the magnification is not too small the S distortion can be sufficiently corrected by electrical means (which we cannot enter into here), but if it is less than 2.75 this is no longer possible. In Fig. K(1) a picture is given showing all three aberrations to a marked extent. The picture in Fig. K(2), however, has only a scarcely perceptible S distortion, which is not troublesome.

The electron gun supplies the scanning beam. Just as is the case with most picture tubes, in the image iconoscope the beam is focused and deflected with the aid of magnetic fields.

In regard to the sharpness of the scanning, there are two things to be considered. The non-deflected beam is focused on the center of the target, where its diameter must be so small that the lines do not overlap when being scanned. If it is desired to work for instance with 1000 lines then, if the height of the scanned part of the target

[5] A review of various optical aberrations is to be found, for instance, in: W. de Groot, *Philips Tech. Rev.*, *9:* 301–308, 1947, in particular pp. 304 and 306.

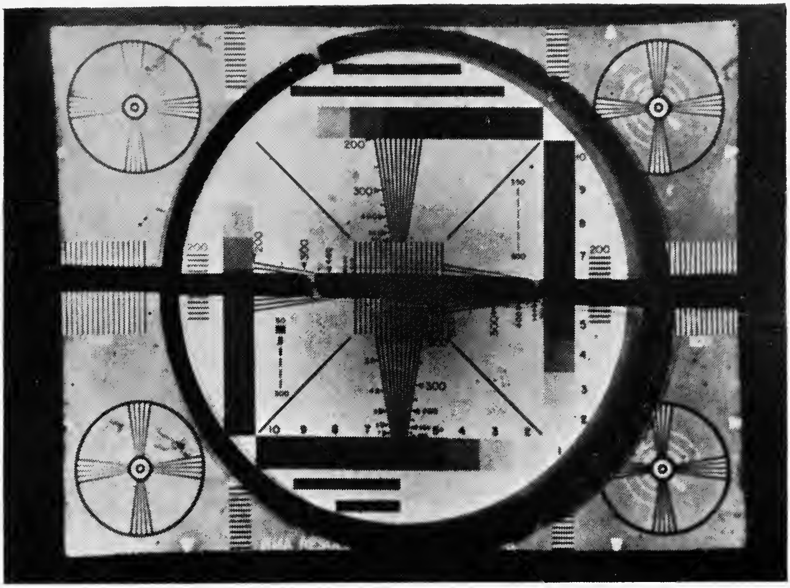


Figure K(2).

is 45 mm, the effective diameter of the focus must not be more than 45μ. This requirement is all the better fulfilled the higher the acceleration voltage is chosen, but this should preferably not exceed 1000 v.

Further, account has to be taken of the fact that in the image iconoscope the electron gun has to be mounted with its axis at an angle to the target. Consequently when the beam is deflected upward or downward the focus is no longer situated on the target. Therefore, to obtain sufficiently sharp scanning also away from the center, the beam must have a good depth of focus, which means that it has to be extremely narrow. Hence the angle of divergence $2\alpha_f$ (see Fig. L) has to be kept very small.

It is, in general, difficult to obtain a fine focus with a very narrow beam on account of the mutual repulsion of the electrons, but fortunately the intensity of the beam current required is very low, in the order of 0.1 μa.

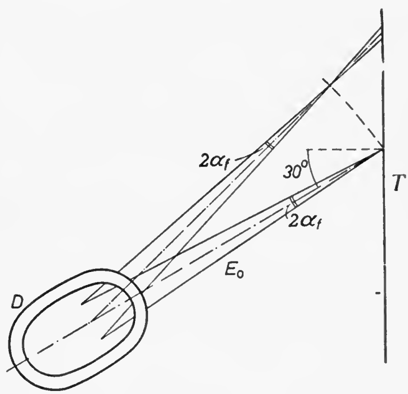


Fig. L. Assuming that the nondeflected beam E_0 has been focused onto the center of the target T, when the beam is deflected the focus will no longer be in the plane of T. This gives rise to blurring, the extent of which increases with the angle of divergence $2\alpha_f$.

In addition to this space-charge repulsion there is another factor limiting the spot size obtained with a very narrow beam: there is a very fundamental relationship between the angle of divergence $2\alpha_f$ and the current density in the beam. In the case where the space charge is negligible this relationship is:

$$\sin^2 \alpha_f = \frac{V_0}{V} \cdot \frac{j_f}{j_0}, \quad . \quad . \quad . \quad . (1)$$

where $V_0 = \frac{1}{2}mv_0^2/e$ (with m = mass, v_0 = initial velocity and e = charge of an electron), V = the potential difference traversed by the electrons, j_f = density of the beam current in the focus, and j_0 that at the cathode of the gun.

What has to be found is an optimum value for α_f at which, on the one hand, the focus is not too large and, on the other hand, the sharpness at the edges of the image does not differ too much from that in the middle. With our image iconoscope the position is such that this optimum value of α_f lies at about 3×10^{-3} radians.

This small angle of divergence, combined with a low beam current intensity (about 0.2 μa), has been obtained by placing two diaphragms in the beam. The first, with a narrow aperture, confines the beam within the desired small angle. The second one, with a wider aperture, allows the beam to pass through without hindrance but intercepts the low-velocity secondary electrons formed round the edge of the first diaphragm.

With the focus of 45 μ already mentioned and a beam current of 0.2 μa, the average current density in the focus is j_f = 12 ma/sq cm. Substituting this in Eq. (1), and for V the value 1000 v, and for V_0 the value corresponding to the average initial velocity ($\approx$ 0.1 v), we find for the average current density at the cathode of the gun $j_0 \approx 120$ ma/sq cm. The peak value of the current density is in fact several times greater. Although an ordinary oxide-coated cathode may indeed be continuously loaded with such a current density, it is better to use what is known as an L cathode,[6] since this has a much longer life. It would be quite undesirable if the useful life of a costly tube such as the image iconoscope were to be dependent upon the life of a component like the cathode of the gun.

The glass arm of the envelope containing the electron gun has been kept as narrow as possible (internal diameter 11 mm, external 14 mm), so that also the focusing coil and the deflection coils may be small. A camera with an image iconoscope is shown in Fig. M.

In practical use the resolving power of the Philips image iconoscope is found to be 900 to 1000 lines in the middle of the image and about 700 lines at the edges. (These limits are set by the electron gun; the resolving power of the electron-optical projection is very much greater.)

An improvement has been reached by coating the mica target with a thin layer of MgO, which leads to a considerable gain in secondary emission and hence sensitivity. Furthermore, owing to the coating of MgO, stains on the mica which cannot be removed and otherwise show up clearly in the picture are thereby made invisible.

The capacitance of a surface element of the target with respect to the signal plate is an important factor, and an increase of this capacitance must lead to greater sensitivity.

New tubes were therefore made with a mica sheet of only about 25 μ thickness (also with a layer of MgO, thin compared with the mica) instead of the original sheet thickness of 50 μ.

The reproduced picture of a scene televised under the normal studio lighting, or of an outdoor scene in daylight

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[6] H. J. Lemmens, M. J. Jansen and R. Loosjes, "A new thermionic cathode for heavy loads," *Philips Tech. Rev.*, *11:* 341–350, 1950.

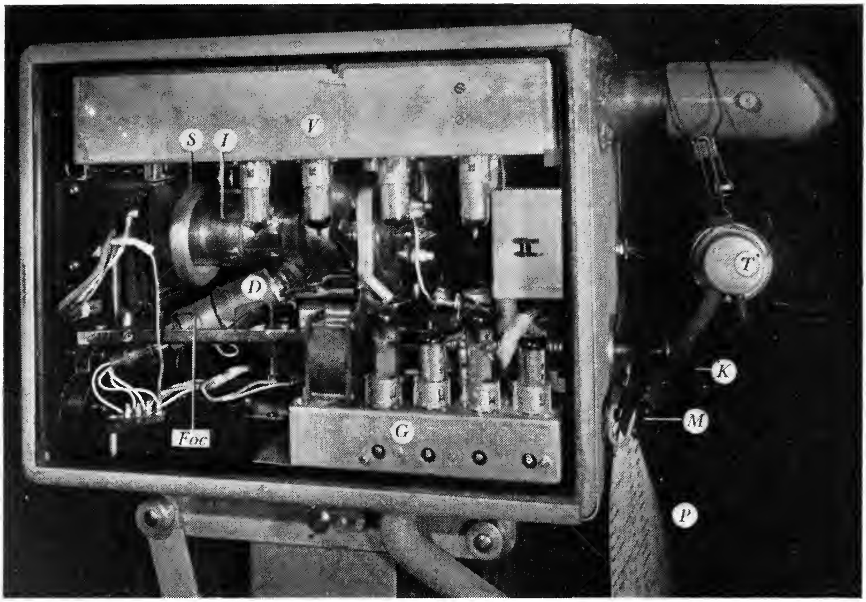

Fig. M. One of the cameras used for the experimental television broadcasts at Eindhoven. One side panel and a screen have been removed. *I*, image iconoscope Type 5854; *S*, image coil; *FOC*, focusing coil; *D*, deflection coils; *G*, time-base generator; *V*, chassis with monitor picture tube and accessories; *M*, microphone and *T*, telephone for communication between the operator and the control room; *K*, knob for exchanging the objective; *P*, playbook.

(even in bad weather), with the image iconoscope last described, is almost free of "noise" and shows excellent gradation.

In the image iconoscope spurious signals arise from the same cause as in the case of the conventional iconoscope: the various surface elements of the target are not all in the same position with respect to the scanning beam. In the image iconoscope, however, the situation is more favorable: with the tube described (mica 25 μ thick, beam current 0.2 μa) and with an illumination producing a photocurrent of more than 0.1 μa, the spurious signals are so weak that there is hardly any need of compensating measures. In practice a photocurrent of 0.1 μa can be obtained with an illumination of the scene of about 1000 lux, when using a non-diaphragmed, normal objective with aperture $f/2$.

Comparison of Different Types of Camera Tubes

Let us now compare, briefly, the two main types of camera tubes, the high-velocity and the low-velocity types.

In the first place there is the question of sensitivity. This resolves itself into two factors (disregarding the efficiency of the optical system), viz. the sensitivity of the photocathode (photocurrent I_{ph} in relation to the light flux falling on the cathode) and the sensitivity of the scanning mechanism (ratio of signal current I_s to photocurrent I_{ph}).

As regards the sensitivity of the photocathode of the two high-velocity tubes — the conventional iconoscope and the

image iconoscope — the latter has very much the advantage, owing to the continuity of the photocathode. Among the low-velocity tubes there are likewise types with a mosaic cathode and others with a continuous cathode, the latter including the image orthicon, which as regards photocathode sensitivity is equal to the image iconoscope.

The scanning sensitivity of low-velocity tubes is simply 1 μa signal current per μa photocurrent. In high-velocity tubes the phenomenon of redistribution complicates matters, but the scanning sensitivity of the ordinary iconoscope can be put at $\frac{1}{20}$ $\mu a/\mu a$ and that of the image iconoscope, at about 1 $\mu a/\mu a$.

Although, therefore, the image iconoscope has about the same scanning sensitivity as the simple low-velocity tube, the $I_s = f(I_{ph})$ curve is not linear, whereas in the case of low-velocity tubes it is linear; the nonlinear curve is favorable, as explained when dealing with the iconoscope.

There is a means, however, of appreciably increasing the scanning sensitivity of low-velocity tubes. The electrons from the scanning beam which are not taken up by the target and return to the gun can be collected in a multiplier, placed around the gun, which works with secondary emission and thus multiplies them. This is what takes place in the image orthicon, commonly employed in the U.S.A. In this way the scanning sensitivity may be raised to a value of 25 to 100 $\mu a/\mu a$, which is of course valuable when scenes have to be televised in poor light. However, the current of the returning beam can be modulated only up to about 20% and consequently contains a relatively large amount of noise.

It has already been explained that in regard to spurious signals the image iconoscope has a decided advantage over the ordinary iconoscope. The image orthicon is free of spurious signals of this nature, but on the other hand it is subject to another interference connected with the fact that the secondary-emitting surfaces of the multiplier do not have exactly the same secondary-emission coefficient over the whole area ("dynode spots").

Electron-optically, high-velocity tubes have undeniably the advantage over those of the other group, in that with electrons of a high velocity it is easier to obtain a scanning beam with a high resolving power, and there is much less trouble from interfering electric and magnetic fields.

TelePrompter — New Production Tool

By FRED BARTON and H. J. SCHLAFLY

The TelePrompter is a device now being used extensively in motion picture and television productions, and by public speakers as an aid in delivery of a prepared script. It is a production tool of great flexibility; its technical features and applications are described.

THE PROBLEM of presenting entertainment to the public has been accentuated by the very nature of the television industry because of its continual requirement for new material. Whether this material is "live," that is, performed directly in front of television cameras or filmed before it is translated into a television signal, the continual demand for new material of an expected quality presents many pressing problems. One of these problems is the fundamental necessity of memorization. Added to the tension that normally accompanies the production of a television or motion picture presentation is the very real and continuing chore of memorization of lines for the actor, and the constant threat of fluffs, delays and retakes for the producer. A professional performer accepts, as part of his vocation, the necessity of studying his lines. Such a professional can substantially memorize new material with comparatively few readings, but in order to reach the point of perfection, the point which makes the difference between a smooth and a ragged performance, this same performer may spend many tedious hours of study. Those who are not normally engaged in the entertainment or public-speaking professions find this problem of memory so much the more difficult. The necessity for accurate memorization breeds a second evil which may be even more devastating to a good performance than the mere fault of forgetting the line. This second evil is the *fear* of forgetting the lines and the resulting tension, tightness and unnaturalness unconsciously generated by such fear.

The TelePrompter is a modern approach to the old problem of prompting. It is a new production tool whose intelligent use can save hours of rehearsal, help to promote a smooth and relaxed performance, and reduce film studio retakes. Not only does its use result in the 100% perfect script without hours of laborious work and mental exercise, but it serves also as a guardian against fear. Paradoxically its mere presence

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Presented on April 21, 1952, at the Society's Convention at Chicago, by Fred Barton and H. J. Schlafly, TelePrompter Corp., 270 Park Ave., New York 17, N. Y.

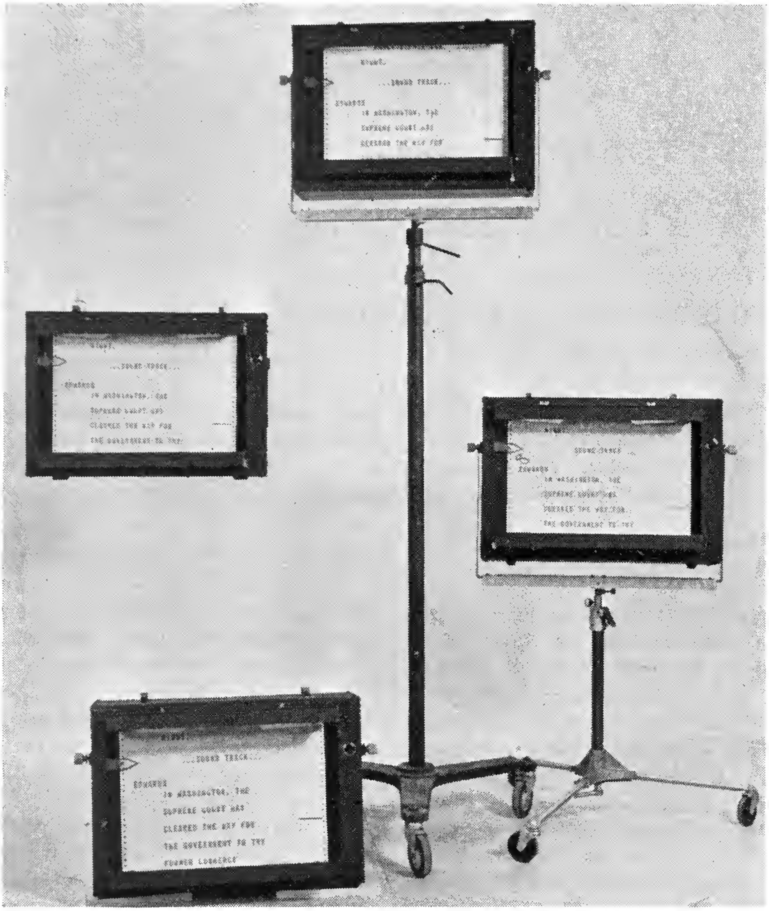

Fig. 1. A group of four TelePrompter reader units illustrating various methods of mounting for studio use.

in a studio greatly reduces the probability that prompting of any nature will be required.

Prompting devices are not new — many methods have been tried throughout the history of entertainment and public speaking. The most familiar of these methods, as far as the public is concerned, is typified by the old prompter's box. Unfortunately, the prompter's hoarse whisper was often as audible to the audience as was the actor's uncomfortable predicament. Even so, the prompter was one of the higher-paid members of the cast. Projection devices of one sort or another have been tried repeatedly, but because of their bulk and the difficulty of making changes they are not in common use. The electronic age contributed a tiny radio receiver with a speaker hidden in the ear of the performer. This method removed the audibility of the cue, but more often than not it distracted the performer with unwanted promptings and confusing instructions, and it bur-

Fig. 2. Master control, operator and monitor TelePrompter. The operator's hand is on the throttle-type speed control.

dened him with equipment that must be hidden on his person.

A careful and lengthy study of the problem pointed out the requirements for a prompting device which would have the features and flexibility necessary to contribute to modern production techniques. This study revealed that, as a primary requisite, a prompting device must be always ready and available for the performer's use if he desired to refer to it without betrayal of that fact to the audience, but it must be a device which could be completely ignored by the performer if he did not need a reference. This basic demand governed the choice of the fundamental TelePrompter design, a design which has successfully withstood the trial by fire of studio use, with only an evolution of details to meet the great variety of individual studio situations that have been met. The TelePrompter is in effect a multiple reader. A number of reading units, usually four for normal studio work as shown in Fig. 1, which are small enough and light enough to be strategically positioned about a set or moved with the action during the shooting, contain the script and acting and production cues. A master control unit, seen in

Fig. 2, comprises the fifth item of equipment in an operational group.

The script is written in large clear black letters on a yellow, glare-free, noncrinkle paper especially developed for this application. The type is front illuminated by self-contained incandescent lights which can be varied in intensity. Front illumination was chosen because it preserves contrast ratio and because it is helped rather than hurt by other studio illumination. Extensive readability tests have been conducted to determine the most favorable combination of the variables affecting vision. The large type is readable without effort by persons having normal or corrected normal vision at 25 ft, a distance that has been found to be quite adequate for the great percentage of studio shots. For an occasional cue many performers have found that distances considerably in excess of this figure are quite satisfactory. The use of low-power enlarging lenses in front of the script, while possible, is discouraged, except on rare occasions. Not only do such lenses add to the bulk and weight of the unit, but they pick up surface reflections, introduce flare and geometric distortions, and so limit the viewing angle that readability generally decreases in spite of the apparent increase in letter size. In those cases where letters larger than the standard Videotype size are required, it is preferred that larger original type be used. Such type is now in the process of being prepared for the electric "Videoprinter" which has been developed for TelePrompter Corporation.

Eight or more lines of script, depending on spacing, are visible to the actor at any one time with the "hot" line, that is the line currently being spoken, indicated by a large red arrow. Thus, the performer is at liberty to precue himself and is not limited to the "hot" line or word only. The script in each reader is printed on a continuous strip of paper which normally passes over the flat reading surface from a supply roller at the bottom to a take-up roller at the top of the machine. In special cases this direction of motion and the direction of script continuity can be reversed.

The use of multiple units is basic to this prompting technique because it frees the performer from the necessity of referring to a particular location on the set. He is at liberty to allow his glance to fall here or there or wherever the director has determined during rehearsal would be the most natural direction for such a glance. Even when the performer is playing to the camera lens, one of the TelePrompter units can be positioned so close to the lens, as shown in Fig. 3, that the slight angular difference in his glance is not significant. In fact, it is convenient to position the "hot" line immediately adjacent to the taking lens itself. The use of multiple units, however, imposes an operational requirement for line-by-line synchronism of the script in the several units so that quick reference may be made from one to the other without losing the place (see Fig. 4).

Several means of synchronizing motion of the script in the individual machines were considered. The most obvious method perhaps would be a pin and sprocket hole arrangement with friction drive of the take-up roll similar to the motion picture projector. This method was discarded for several reasons: it is not suitable for operating over the great range of speeds that are required; the pins demand precise location of the paper on the rollers and precise alignment of inserts and changes; stretch and shrinkage of paper as a function of weather make loading difficult; full drive power must be transmitted to the paper by small-diameter pins in a few sprocket holes; and misalignment of the paper or rollers can cause noise and even tearing of the paper. In the TelePrompter the take-up roller is driven by direct gearing to the motor pinion. Tension is applied to the paper by friction braking of the

supply roller. For reversing, the motor pinion is caused by remote control to disengage the take-up gear train and to engage the gear train of the supply roller. In either forward or reverse, one-way clutches remove friction from the drive roller and apply it to the feeding roller.

Torque for each machine is provided by a small-size selsyn motor connected electrically to a large self-synchronous generator in the master control unit. The generator is motor driven through a mechanical speed changer which is

Fig. 3. The small Model 3 TelePrompter reader with camera mount attachment on the friction head can position the "hot" line immediately adjacent to the camera lens.

Fig. 4. Dramatic shows such as the *First Hundred Years* make use of the TelePrompter.

continuously variable from zero to maximum speed. Various simplifications of this drive system are, of course, available at the cost of certain operational features. This drive system was chosen not only because of the synchronous rotation of all rotor shafts in the system, but because the motors operate well over a great range of speed and are quiet, both mechanically and electrically.

While the self-synchronous system provides the basic unit synchronism, it does not protect against insertion errors or cumulative errors of line spacing in the printing or slight differences in paper tension. A further precaution was added not only to guarantee the line-for-line synchronism required, but to provide an additional degree of flexibility of individual unit control. This feature consists of small conductive strips placed at short intervals along the script. Normally these so-called synchronizing marks are placed in identical positions on the several script copies. As the paper travels past the reading aperture a pair of contacts engages these marks making a temporary electrical circuit. Should one machine reach a particular synchronizing mark on its script before that point has been reached in the other machines, a relay circuit operates causing that machine to stop. When all machines have reached that identical point in the script, a reset relay operates and they continue resynchronized. Normally synchronization marks are located at periodic intervals of about four feet.

Mention has been made of the "great range of speed" required in operation of the machine. Possibly some explanation is required on this point. An operator, located at the master unit, has control not only of the TelePrompter lighting, cue lights, synchronization and mode of operation, but also of the speed of the script motion. This operator is, if you will, the accompanist. He regulates the speed of the script so that the "hot" line is always on the red arrow indicator of his monitor unit. If there is no dialogue at a particular moment or if the actor chooses to ad-lib, script speed may be zero. With normal monologue the speed may be very slow. A lively dialogue may require a speed several times normal, and a program cut or change in continuity (even that happens occasionally while "on the air") may require a speed many times normal. Rehearsals, of course, place a maximum demand on speed variations since the script must be brought forward or reverse to any particular spot for a run-through in less time than the other studio preparations can be made for that run-through.

An important feature of a modern prompting device is speed not only in preparation of the script, but speed in making changes. TelePrompter scripts are prepared by an electric "Videoprint" typewriter with paper supplied in fanfold packs for an original and three carbon copies. The carbons have been chosen by laboratory tests for good contrast and the copies are in fact hardly discernible from the original. Although the paper and type size of the "Videoprinter" is large, it has a standard typewriter keyboard and is operated easily and conveniently by any typist.

Small script changes can be made simply by an ink-brush write-in either directly on the paper or on a cloth adhesive tape placed over the changed word or line. Larger changes are made by removing or inserting complete panels in the paper. A panel consists of one fold of the original paper, an eight-inch length for the standard TelePrompter. The paper is supplied by the manufacturer with accurate horizontal perforations between panels for ease in tearing out sections.

Accessories for studio operation include various types of mobile and stationary stands or stand attachments for mounting the TelePrompter units. A newly developed camera mount, used to support

the TelePrompter, shown in Fig. 3, is the most recent addition to the accessory line. This mount is installed between the friction head of the pedestal or tripod and the camera. It permits quick and easy adjustment of the center of gravity of the camera so as to balance the weight load of any other camera accessory with respect to the axis of tilt. A TelePrompter unit can be supported by this mount so that it is fixed with respect to the taking lens, regardless of camera motion. Furthermore, it is supported in this position without hindering the operation or accessibility of the camera in any way, and without obstructing the view of the cameraman, while retaining perfect balance of the camera on the friction-head assembly. Although developed primarily for the TelePrompter, the camera mount already is a ready and excellent solution to other camera-balancing and accessory-mounting problems and is now being used for that purpose.

The TelePrompter is a modern solution to an old problem that has been aggravated by urgent production schedules. It is a new tool, flexible enough to be fitted to particular production problems, placed at the disposal of the director to save time, to reduce tension and to help achieve a smooth performance.

The Synchro-screen as a Stage Setting for Motion Picture Presentation

By BENJAMIN SCHLANGER, WILLIAM A. HOFFBERG and CHARLES R. UNDERHILL, Jr.

The Synchro-screen* is described as consisting of a motion picture screen with contiguous reflecting side wings, top and bottom panels. The picture surround surfaces synchronously fluctuate in light intensity and color with the changes in picture light and color adjacent to the reflecting surround areas. There is an appreciable increase in the subtended angles of the luminous field of view of the theater patron. A luminous, maskless stage setting is thus created for the viewing of motion pictures.

It is a well-known fact that ophthalmologists, and others concerned with the care of the eyes, do not advise any condition where there is a high central but inadequate peripheral illumination. Reading a book or working under a shaded lamp in an otherwise darkened room is known to cause eye fatigue and even injury. The conventional black masking used with the motion picture screen is a glaring example, on a larger scale, and has been denounced by lighting specialists for years.

Luckiesh and Moss[1] have proven that certain eye muscles become fatigued from strain under the condition of dark surroundings and that the strain is relieved when there is some general peripheral lighting available without changing the brightness of the central objects. Employees in modern industry are no longer required to work under purely localized light sources, because employers know that the effects of dark surroundings for any visual task are psychologically depressing and that associated eyestrain and fatigue will result. The armed forces have given much thought to avoiding a dark surround on certain instrument panels and radar screens by incorporating a lumi-

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Presented on April 22, 1952, at the Society's Convention at Chicago, by R. H. Heacock for the authors, Benjamin Schlanger and William A. Hoffberg, Theatre Consultants, 35 W. 53d St., New York 19, N.Y., and Charles R. Underhill, Jr., Radio Corporation of America, RCA Victor Div., Engineering Products Dept., Camden, N.J.

* Manufactured for and distributed by RCA.

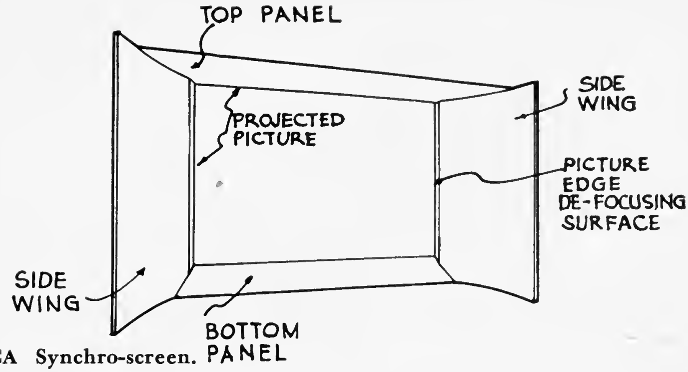


Fig. 1. The RCA Synchro-screen.

nous surround area in the design of military equipment.

Manufacturers of home television receivers were quick to recognize the importance of having the most favorable viewing conditions for a highly competitive product. An obvious difference in the viewing of home television and theater motion picture images is that home television receivers generally have light gray masks, whereas the conventional motion picture screen has black masking — a device as old as the motion picture industry.

The viewing of motion pictures in theaters is one of many visual tasks that are performed daily for prolonged periods by millions of people. Audiences, from the earliest days of the art, have never complained about prevailing lighting conditions until they have had better conditions for comparison. It is then that the older conditions are judged primitive. Therefore, the public has been inclined to accept black masking on motion picture screens, just as it has accepted primitive lighting conditions in other fields.

The Synchro-screen completely eliminates the black masking and complies very effectively with two distinct steps in the disposition of lighting as suggested by Luckiesh and Moss[1]:

(1) the attainment of maximal visibility within the central field without regard to the surroundings and

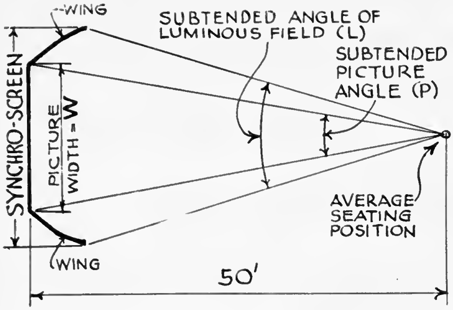
(2) the lighting of the surroundings in such a manner as to produce maximal comfort and ease, and minimal loss of visibility in the central field.

The first step is effectively attained by the use of a gradationally perforated sound screen known commercially as the Evenlite screen.[2] The design of the surround, which is the outstanding feature of Synchro-screen, adequately meets the requirements specified in the second step. The necessity of coordinating the requirements of both steps in the design of a screen stage setting is emphasized in the words of Luckiesh and Moss[1]:

"The important positive contribution to the lighting of the surroundings is the creation of conditions that will provide maximal visual and mental relaxation, minimize eye strain and fatigue without causing undue distraction from the picture, and promote safety. This means a proper balance or compromise of these factors."

In connection with these conditions, they have noted that the use of fixed, colored light appears unadvisable in the surrounding field for the same pyscho-physiological reason as darkness and glaring sources. By reflecting the light and color of the projected picture to the surround, the Synchro-screen has avoided this disadvantage.

Fundamentally, a Synchro-screen stage assembly consists of the main



SUBTENDED ANGLES L & P						
	No 10 WING		No 8 WING		No 7 WING	
	24'W	20'W	20'W	16'W	16'W	12'W
L	45°32'	40°46'	36°52'	32°2'	30°14'	25°20'
P	27°0'	22°38'	22°38'	18°10'	18°10'	13°42'
L/P	1.69	1.80	1.63	1.77	1.67	1.85
AVERAGE INCREASE = 73% = $\left(\frac{L-P}{P}\right)$						

Fig. 2. The proportion of luminous surround area to picture area varies from 90% to 120% based on subtended horizontal and vertical angles of Synchro-screen from above seating position.

picture screen and frame to which is added a surround screen area comprising two side wings, a top panel and a bottom panel, as shown in Fig. 1. The two wings, as well as top and bottom panels are basically screens and frames of special designs, so that the stage setting assembly consists essentially of five screen surfaces and frames arranged in a definite relation to each other and to the projected picture light. In the same manner that the conventional black masking reduces slightly the maximum projected picture area for the purpose of concealing the projected edges of the picture aperture, so are the four surround panels of Synchro-screen set to enclose a picture area slightly smaller than that projected, in order that the edges of the projected picture will fall on the surround screens very close to their inside edges. The design and positions of the surround screens cause the image of the picture edges to be so completely out of focus that no borders are discernible from the seating area. Neither colored aberration edges nor borderline picture jump are noticeable.

The screen surfaces of the surround area receive and simultaneously reflect diffused light from the relatively adjacent areas on the picture screen in such a manner that the intensity of light and the predominant color of the adjacent picture area are reflected *synchronously* from the surround panels to the audience as a blended extension of the picture in light intensity and hue. At no time during the presentation of a picture on the Synchro-screen is the brightness of the surround area as bright as the nearest area of the picture. Therefore, there is never any distraction of the attention from the picture itself.

It can be seen from Fig. 2 that there is an appreciable and dramatic increase in the luminous field of view produced by the Synchro-screen. The picture seems larger and therefore closer to the audience because the subtended picture angle is related by the eye to the synchronous, luminous surrounding field which has a subtended area of from 90% to 120% of the picture area. The average increase in subtended horizontal angle to the luminous field is about 73% and produces a strong horizontal extensional effect which approximates the relatively subdued luminosity of the monocular portion of the field of view.

Synchro-screen Stage Setting Assemblies are manufactured as a complete package in 17 sizes, beginning with a minimum projected picture width of 12 ft and increasing by 1-ft width steps up to about 30 ft as a practical limit.

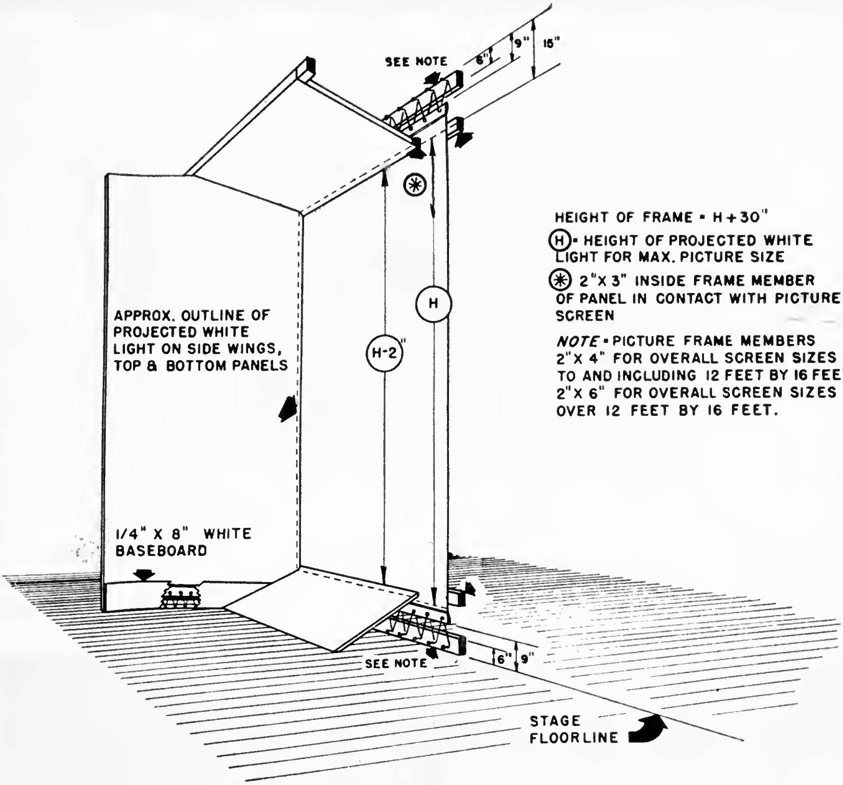


Fig. 3. Relation of panels to picture screen.

The picture screen, as previously mentioned, is the Evenlite screen described in a paper presented at the April 1951[2] meeting of this Society. The fact that this screen has no perforations in the side areas has three important effects: firstly, the screen material of the wings exactly matches the sides of the picture screen; secondly, the side areas of the picture screen reflect the maximum amount of light so essential for optimum illumination of the surround; and thirdly, the Evenlite screen has been found to be a practical solution to the problem of obtaining an optimum screen brightness of an essentially uniform value in foot-lamberts from all points on this screen's surface.

Synchro-screen shipments are made knocked down. Total shipping weight for a picture size of 15 by 20 ft is about 800 lb. The five screen surfaces used in the complete assembly are shipped in tubes and the structural frame members are strapped into bundles with the exception of the top and bottom panel frames which are prefabricated into half sections for more rapid assembly on the job. Hardware is included in a kit of assembly parts and instructions. All members are lettered for ready identification and match marked for easy assembly. Basically, the installation of a Synchro-screen requires the erection of five frames and screens of various sizes (comprising the picture screen, the left and right side wings, the top and bottom panel) with wings and panels in

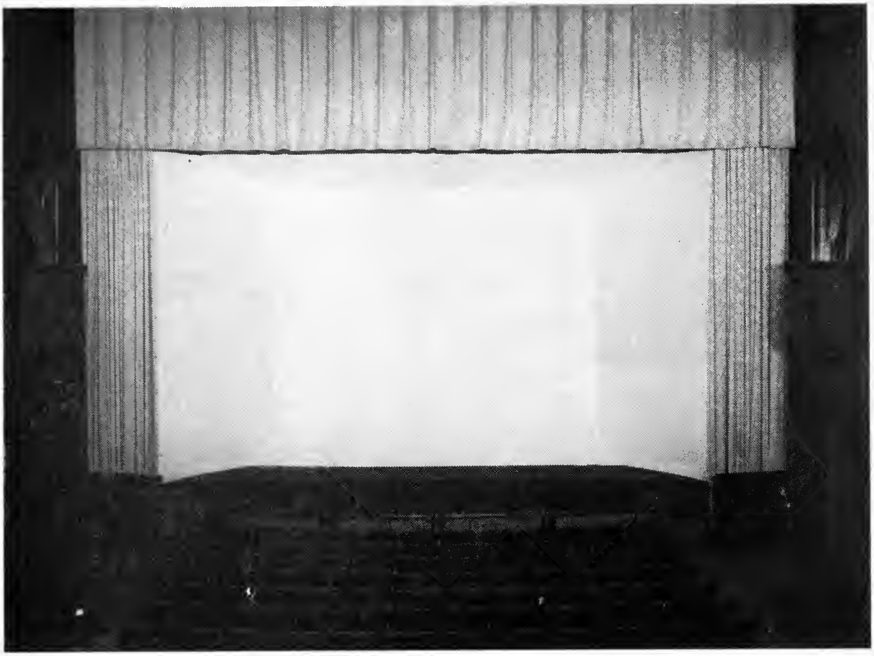


Fig. 4. Synchro-screen installed in the Plaza Theatre, New York City.

proper relation to the picture screen (Fig. 3). The picture screen is face-laced to bring the screen surface in a plane where the wings and panels can be in close contact. The screen material is Firestone Velon made to RCA specification. It is wrapped around those edges of the wings and frames which are in contact with the picture screen or exposed to view.

Architecturally, the Synchro-screen presents the appearance of an orderly, organized and attractive stage setting for motion picture presentation. It offers an economical method of creating a new atmosphere in the zone of maximum patron attention in the auditorium. The use of a draw curtain in front of the Synchro-screen has been found to have dramatic value, especially when the large luminous reflecting surfaces gradually come into view as the performance begins. A photograph of a Synchro-screen installation (Fig. 4) in the Plaza Theatre, New York, illustrates the use of a curtain and valance of a light gold-tint material.

Without an interest in or prolonged attention to the picture presentation (conditions which a theater patron assumes), an initial and momentary casual appraisal of the surround surfaces may result in a negative first impression, such as one of distraction. However, it must be remembered that the patron desires to concentrate on the main picture dramatic development. At such times, the Synchro-screen surround areas are in the peripheral field of view since the human field of view tends to become narrower when pyschological concentration exists. Distraction is completely eliminated when concentration occurs.

That the Synchro-screen is easier on the eyes, gives the effect of better color,

causes an illusion of added width and height, and creates an atmospheric effect is repeatedly attested to by patrons in unsolicited statements to theater personnel. From an audience reaction viewpoint, estimated as at least 100,000 persons to date, Synchro-screen has proven to be a major improvement in the presentation of motion pictures in theaters.

References

1. M. Luckiesh and F. K. Moss, "The motion picture screen as a lighting problem," *Jour. SMPE, 26:* 578–591, May 1936.
2. C. R. Underhill, Jr., "Practical solution to the screen light distribution problem," *Jour. SMPTE, 56:* 680–683, June 1951.
3. B. O'Brien and C. M. Tuttle, "Experimental investigation of projection screen brightness," *Jour. SMPE, 26:* 505–517, May 1936.
4. B. Schlanger and W. A. Hoffberg, "New approaches developed by relating film production techniques to theater exhibition," *Jour. SMPTE, 57:* 231–237, Sept. 1951.
5. B. Schlanger, "A method of enlarging the visual field of the motion picture," *Jour. SMPE, 30:* 503–509, May 1938.

Discussion

R. H. Heacock: You know, Barton, I have a confession to make about Synchro-screen. I, like most of you, have heard Ben Schlanger talk about light surround areas as applied to motion picture screens for some years. Since there are very few new theaters that can be constructed like that at Framingham (which was originally designed and built for a light surround screen), as compared to our twenty-thousand existing theaters, my interest was only academic.

From a practical viewpoint, another factor colored my reaction to Ben's ideas. I think most of you have experienced what I refer to. We are told most seriously of the marked advantages of the dissolving action of double shutter projectors; of the greater, whiter light of a certain arc lamp; of the longer, flatter response curve of a particular theater sound system. And yet we who tell you of these wonders would be hard pressed to tell you with absolute certainty specifically what equipment was in the booth of a particular theater where you might ask us to see and hear a current Hollywood release with you.

Last fall I saw the first installation of Synchro-screen. Each time I watch another picture on this screen I become more convinced that this packaged stage setting will do more to improve an existing theater's film presentation than the same amount of money could if spent for any other improvement.

Each of you has been given a courtesy admission card at the time of registration to the Palace Theatre to see an actual operating theater equipped with Synchro-screen. If you want to see how a technical idea has been adapted to actual operating conditions, take a ten-minute cab ride, see one reel of the feature, and then we believe you will understand the great interest in this practical modern method of stage setting for presentation of our current Hollywood productions.

W. R. Cronenwett: I'd like to ask whether Synchro-screen equipment can be so designed to be flown to a grid?

Mr. Heacock: It probably can, but at the present time we do not have such equipment. Our current installations are set up and are rigidly assembled to the stage floor. With any special requirements like that, we would be very happy to discuss them in detail with you and I think it's always possible to overcome difficulties of that kind if there is money enough in the kitty to pay for this special feature.

J. A. Tanney: Does the name Synchro-screen come from the fact that the lighting in the surround varies with the brightness of the image on the screen?

Mr. Heacock: That's exactly right. In England I saw a write-up in the *International Projectionist* where they took the light from the frame that was four frames above the actual projected picture. Some of the light was diverted up through an associated optical system and then projected around the edges of the main picture screen. My interpretation of that article would be that if we had a Technicolor feature, we would have a surround area that would be a blend of all of the colors in that particular frame. One other thing, it is out of sync by the amount

of four frames. For those of you who may have seen the *Desert Fox*, there was quite a sequence of an artillery barrage where you would see a blast of light and in silhouette, a gun crew in this corner of the picture screen and in a fraction of a second there would be another flash of light up here, and finally there were flashes here, here and here. I happened to see that on Synchro-screen and, of course, in exact synchronization the whole area of the side wings and bottom wings flashed into view here and up here, then here, and then over here, so that truly the word Synchro-screen is not just a trick name, but has meaning. The surround areas are in perfect synchronization not only with light variation but also with variation in color intensity.

If the area at the left side is blue, the wing on that side is blue. If the upper righthand corner is dark red, the surround area there is dark red.

Anon: Where can this screen be seen in New York?

Mr. Heacock: The Plaza Theatre on 58th Street and Madison Avenue has the Synchro-screen, as does the Plaza in Scarsdale, New York.

R. L. Estes: I'm interested in knowing how the light surround reflected from the wings affects the shadow detail and also what is the effect of viewing from different angles the width of the wings?

Mr. Heacock: Although I have seen six or eight different feature films in various theaters equipped with Synchro-screens, I have not been aware of any washing out of the picture at the edges. Although theoretically a very small amount of light might be diffused back on to the edges of the main picture screen, from a practical viewpoint this effect is not perceptible. I have not heard any criticisms of the screens in this respect from any others who have seen them.

When I first saw Synchro-screen, I moved around from the center of the balcony to the sides of the balcony, to close-up on the right, and close-up on the left. There is a variation. There is a change, but I didn't sit in any seat where I had any but a favorable reaction and my own feeling was that here was something that would really have popular appeal. I believe that your question depends a great deal on your own personal reaction; consequently, I strongly recommend that you go down to the Palace Theatre here in Chicago and check into each of these points, and I shall be very much interested in hearing of your own personal conclusions.

You'll notice in the advertisements of the Palace Theatre — I cut this out of the paper this morning — it says here in capital letters: SEE THIS GRAND PICTURE ON OUR NEW THREE-DIMENSIONAL SYNCHRO-SCREEN. We know that this is not three-dimensional, but I think if you happen to see a picture — the ballet sequence in *An American in Paris* was mentioned here this morning by Mr. Handley — you would be almost willing to declare that you did see a three-dimensional picture. But it's the same picture on the same plane, flat picture screen. The psychological effect of the light surround area, I do think, tends to help in your feeling of a three-dimensional effect. But technically, of course, it is not.

C. L. Greene: Is there, in Chicago, an installation of Ben Schlanger's original type of screen, where the margins of the screen transmitted some picture light to a reflective surface behind it, a specular reflecting surface which then reflected that light out on to side wings.

Mr. Heacock: I do not believe there is. I don't know if there is such an installation.

Mr. Greene: That was demonstrated with a model in New York, I believe, in 1937. I heard the comment repeated many times at that meeting, that that was the greatest advance in picture presentation since the coming of sound. Personally, I still subscribe to that opinion. It is not flattering, I think, to the exhibition branch of the industry that it has shown an almost psychopathic fear of advancements such as this. I am in a way sorry to see it come in a package form which I fear is not the equal of Mr. Schlanger's original design, but at the same time I am happy to see the industry accept any improvement.

Mr. Heacock: Well, go down to the Palace and see how you like it. I'll be very much interested in talking to you about it.

Resolution Test Chart of the Motion Picture Research Council

THE MOTION PICTURE RESEARCH COUNCIL has announced the preparation of a resolution test chart designed primarily for the use of studio camera departments. When mounted in front of a 35mm camera lens at a distance in inches equivalent to the focal length of the lens in millimeters, its image exactly fills a standard 35mm aperture (American Standard Z22.59-1947). Resolution test figures in key positions over the field will then indicate limits of resolution directly in lines per millimeter. Other test patterns give qualitative indications of serious aberrations or other lens defects while carefully designed focus figures at the center and each corner assist in studies involving depth of focus and curvature of field.

Although designed primarily for use with 35mm camera lenses, the chart may be used satisfactorily with any photographic lens. It may not fill the field at the specified distance, but simple conversions of the indicated scale units can be used without difficulty. An illustration of the chart is included. It is printed on white card and has an overall dimension of approximately 16 by 22 in. Copies may be obtained for $3.00 each, postage prepaid, directly from the Motion Picture Research Council, 1421 North Western Ave., Hollywood 27, Calif. "Directions for Use" accompany each chart.

Articles describing the development and construction of the chart have been published:

1. Armin J. Hill, "A new resolution test chart for motion picture camera lenses," *Phot. Sci. and Tech.* (*Sec. b*, *PSA Jour.*), *17:* 68–70, Sept. 1951.
2. Armin J. Hill, "A resolution test chart for motion picture cameras," *Am. Cinematographer*, *32:* 402, Oct. 1951.

Fig. 1. Detail of focus figure.

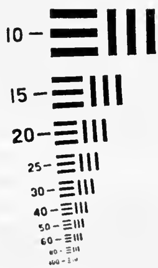


Fig. 2. Enlarged detail of the resolution pattern.

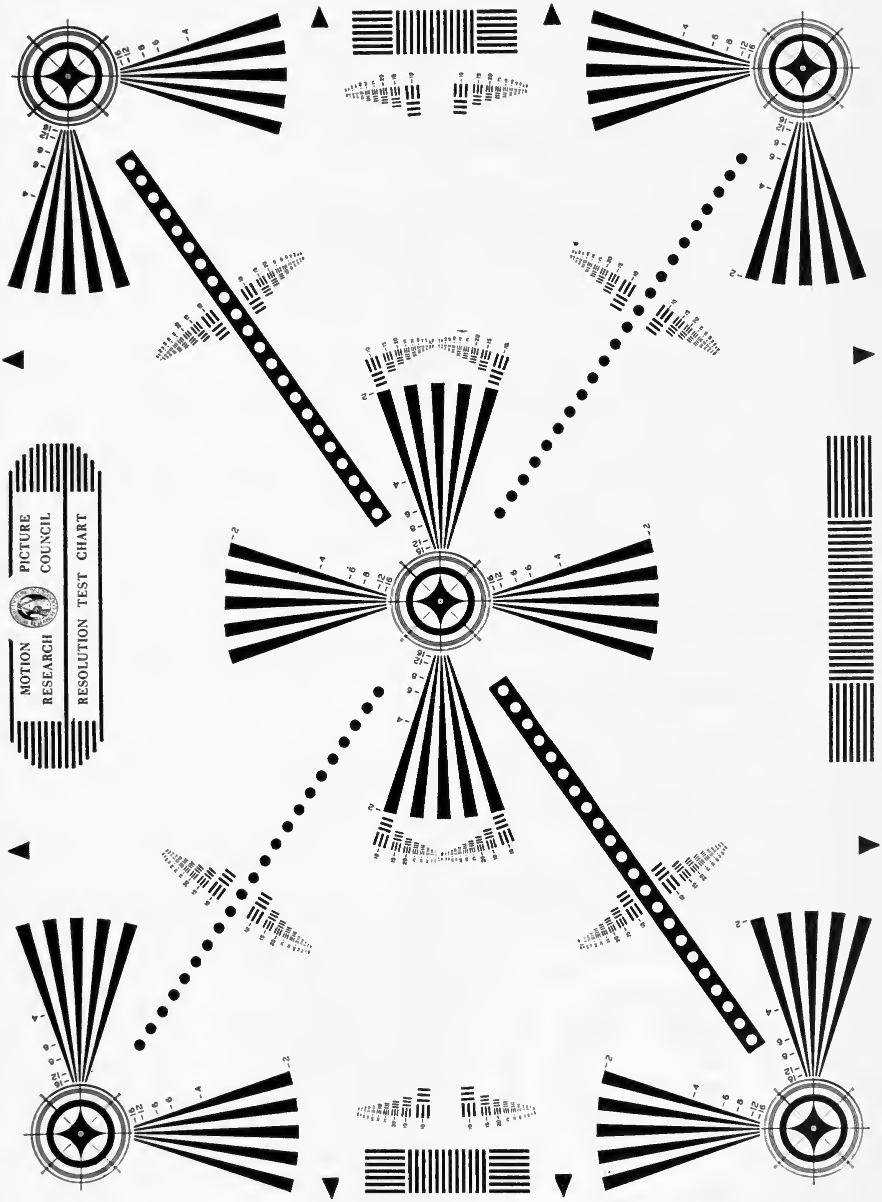


Fig. 3. Motion Picture Research Council Resolution Test Chart

Laboratory Practice Committee Report

By JOHN G. STOTT, Committee Chairman

This committee was organized under its present Chairman and Committee personnel early in 1949. The original agenda of this Committee was thought to be concerned primarily with chemical and chemical engineering problems associated with the motion picture industry. The proposed agenda was directed into these particular channels primarily because the membership of the Committee was composed largely of chemists and chemical engineers working in motion picture laboratories. The first meeting of this Committee, however, brought out rather clearly that there were many problems to be considered before too much effort was expended on purely chemical and chemical engineering problems.

At the Committee's first meeting the following proposed agenda was laid out:

1. Design of a special leader for television films to replace the Academy theater leader.
2. Aid in the standardization of screen brightness for 16mm projection.
3. Establishment of a standard for the notching of 35mm and 16mm negative films.
4. Investigation of the possibility of modifying sound and picture reduction printers to print forward and backward and to employ 2000-ft negative feed and take-up.
5. Investigation of the standardization of edge numbering of 16mm films.
6. Study recommendations for the splicing of 16mm films.
7. Study 16mm projection emulsion position.
8. Study methods of bringing data on chemical and chemical engineering developments to the attention of Society members.

This Committee is able to report as follows on the agenda laid out early in 1949:

1. A special leader for television films to replace the Academy theater leader has been designed, submitted to the membership of the Society for comment, has been approved, and is currently in widespread use throughout the industry. The work on this leader has been carried out by the Leader Subcommittee of the Films for Television Committee under the Chairmanship of Charles Townsend. The representative from the Laboratory Practice Committee on the Leader Subcommittee was V. D. Armstrong.

2. A subcommittee on 16mm review-room screen brightness of the Laboratory Practice Committee under the Chairmanship of O. E. Cantor has

Presented on April 24, 1952, at the Society's Convention at Chicago, Ill., by John G. Stott, DuArt Film Laboratories, 245 W. 55 St., New York 19, N. Y.

drafted a Proposed American Standard for screen brightness of 16mm laboratory review rooms. One criticism of the Proposed Standard concerns the discrepancy between the established standard for 35mm and the proposed standard for 16mm. It is felt, however, that due to the extremely difficult conditions under which 16mm films are projected, particularly in Armed Forces installations, a screen brightness standard identical to the 35mm standard would in most cases be unattainable and hence, unrealistic. The problem is further complicated by the amateur and television fields.

3. The Proposed American Standard on Size and Location of Notches for 35mm Negatives was drawn up by Paul Kaufman and was submitted to the Laboratory Practice Committee for balloting. Considerable opposition to the Standard arose from the Committee members because many printers in the industry could not be made to conform to this Standard without extensive and expensive alterations. It was also learned that many thousands of reels of negatives are presently stored in laboratory vaults from which prints are ordered from time to time, these negatives being notched in accordance with past practice and hence, in many cases being notched contrary to this proposed Standard.

At a later meeting of the Laboratory Practice Committee it was decided that it would, at the present time, be impossible to arrive at any compromise which would make it desirable to adopt this Standard. It was also felt that it would be much simpler to establish a standard for 16mm films since the need for a notching standard in 16mm is so urgent. Further observations were that the method of "notching" would have to be totally different and distinct from past methods and also essentially noninterfering with presently notched films in order to make the establishment of a standard even remotely possible.

Lloyd Thompson had been working on other means of "notching" 16mm films and offered to turn over to the Society any methods, patents or licenses, free of charge, providing this information would aid in the establishment of an American Standard. Mr. Thompson, after a great deal of research and development, has devised a means of actuating light-change mechanisms by means of applying an electrical conducting material to the emulsion of the film which may be used as a cueing device for such light-change mechanisms. Mr. Thompson has prepared a report outlining the history and background of printer light-change cueing methods and proposals and has drawn up a Proposed American Standard. This report is complete in all respects including drawings of the mechanical elements required, amplifier circuits, parts list and approximate prices. This report was submitted to the Laboratory Practice Committee for balloting early in April 1952.

This Proposed American Standard makes it possible to provide printer light-change cueing of 16mm negatives whether they have been notched before or not. It is hoped that when this method of cueing of 16mm negatives has been adopted as an American Standard, the same technique may be applied to 35mm, thus solving the 35mm notching problem.

4. The manufacturers of motion picture printers were contacted regarding the possibility of modified sound and picture reduction printers to print forward and backward and to employ 2000-ft negative feed and take-up. It was the unanimous opinion of the equipment manufacturers that modification of sound and picture reduction printers now in use to print forward and backward would entail extensive modification of present equipment and would involve considerable increase in price in future models. It was the opinion

of the Committee membership that it was not a function of the Laboratory Practice Committee to propose to equipment manufacturers changes of this type, but was rather a matter concerning negotiation between equipment manufacturers and the purchasers of the equipment.

With regard to the use of 2000-ft negative feed and take-up assemblies on these printers, it was learned that some manufacturers of this type of equipment were already turning out printers so equipped. Existing equipment in laboratories in many cases had been altered by their engineering departments. It was thus decided that this matter should be tabled.

5. At the time the Laboratory Practice Committee investigated the standardization of edge numbering of 16mm films, a Proposed American Standard was already in the process of being drafted by the 16Mm and 8Mm Committee of the Society. This Standard has now been submitted to ASA for balloting.

6. In spite of a great deal of discussion in Laboratory Practice Committee meetings, it was impossible to arrive at any conclusions regarding recommendations on the splicing of 16mm films. A standard for splicing of 16mm positive films was drafted by the 16Mm and 8Mm Committee and has just been approved as an American Standard.

7. The matter of 16mm projection emulsion position has been discussed thoroughly in several engineering committees of the Society including this one. A symposium on this problem was held at the Hollywood Convention in October 1951, but the matter seems still to be completely up in the air. It is certain that the entire membership of the Society is familiar with the problems of 16mm projection emulsion position and hence, no further amplification is required here.

8. Under the editorial direction of Irving Ewig, the Laboratory Practice Committee has been contributing to the *Journal* under the heading of "Chemical Corner" which includes suggestions, tips, new methods, new equipment and new techniques related primarily to chemical and chemical engineering problems. This project requires a great deal of time on the part of Mr. Ewig and it is hoped that Committee members and the membership at large of the Society will aid Mr. Ewig in this work by submitting interesting material.

Since this agenda was proposed, other projects have been referred to the Laboratory Practice Committee for comment and action.

At the Lake Placid meeting of the Committee on Color, it was pointed out that a definite need exists for the establishment of a standard magnification ratio for the production of 35mm color prints from 16mm preprint material. The Committee on Color recognized this as a laboratory problem and recommended that this project be assigned to this Committee. This project was undertaken by Gordon Chambers, who prepared a proposed 16mm optical printer aperture for enlargement printing to 35mm. This Proposed American Standard examines several possible solutions and recommends what appears to be the most logical choice. The Laboratory Practice Committee has been balloted on this Standard and, as a result of the voting, this Proposed Standard has been submitted to the Standards Committee for processing.

At the Convention held in Chicago in April 1952, another meeting of the Laboratory Practice Committee was held. At this meeting the Proposed Standard on screen brightness for 16mm laboratory review rooms was discussed at quite some length. Considerable opposition to the proposed brightness was raised because of the wide divergence from usual projection screen brightness

for 16mm amateur films. It was recommended that the Screen Brightness Committee as well as this Committee be balloted and that further action be held up until the results of the voting are known.

At this meeting it was also decided that this Committee would embark on a program of drawing up definitions or a system of nomenclature for all chemical operations found in motion picture laboratories in order to clarify terms in technical discussions and literature. Should this chemical glossary prove successful, future plans would include expansion of this glossary to include all laboratory products, equipment and functions.

Standards for Splices and Projection Reels

On April 30, 1952, the American Standards Association approved one new standard, PH22.77-1952, Splices for 8MM Motion Picture Films, and revision of two previous standards, PH22.24-1952, Splices for 16MM Motion Picture Films for Projection, and PH22.11-1952, 16MM Motion Picture Projection Reels.

All three standards were initiated and/or revised by the 16MM and 8MM Committee. The splice standards were published for trial and comment January 1951 and the reel standard first in February 1950 and again in February 1951 when the initial publication resulted in comments indicating a need for further revisions.

American Standard

for

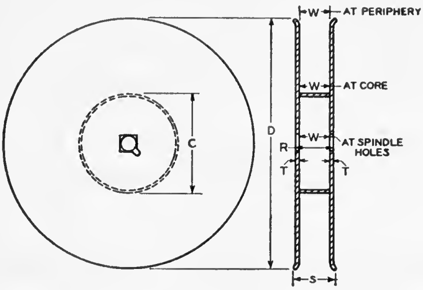
16-Millimeter Motion Picture Projection Reels

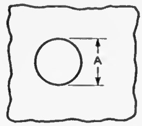
ASA
Reg. U. S. Pat. Off.

PH22.11-1952

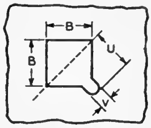
Revision of
Z22.11-1941
and
Z52.33-1945

•UDC 778.55





ENLARGED VIEW OF HOLE IN FLANGE ON LEFT IN SECTIONAL VIEW SHOWN ABOVE



ENLARGED VIEW OF HOLE IN FLANGE ON RIGHT IN SECTIONAL VIEW SHOWN ABOVE

Table 1

See page 3 for notes.

Dimension	Inches	Millimeters
A	0.319 $^{+0.000}_{-0.003}$	8.10 $^{+0.00}_{-0.08}$
B	0.319 $^{+0.000}_{-0.003}$	8.10 $^{+0.00}_{-0.08}$
R[1]	0.790 maximum	20.06 maximum
S[2] (including flared, rolled, or beveled edges)	0.962 maximum	24.43 maximum
T (adjacent to spindle)	0.027 minimum 0.066 maximum	0.69 minimum 1.68 maximum
U	0.312 ±0.016	7.92 ±0.41
V	0.125 $^{+0.005}_{-0.000}$	3.18 $^{+0.13}_{-0.00}$
W, at periphery[3]	0.660 $^{+0.045}_{-0.025}$	16.76 $^{+1.14}_{-0.64}$
at core[4]	0.660 ±0.010	16.76 ±0.25
at spindle holes	0.660 ±0.015	16.76 ±0.38
Flange and core concentricity[5]	±0.031	±0.79

Approved April 30, 1952, by the American Standards Association, Incorporated
Sponsor: Society of Motion Picture and Television Engineers

•Universal Decimal Classification

American Standard

for

16-Millimeter Motion Picture Projection Reels

ASA
Reg. U. S. Pat. Off.

PH22.11-1952

Table 2

Capacity	Dimension	Inches	Millimeters	Capacity	Dimension	Inches	Millimeters
200 feet[6] (61 meters)	D, nominal	5.000	127.00	1200 feet (366 meters)	D, nominal	12.250	311.15
	maximum	5.031	127.79		maximum	12.250	311.15
	minimum	5.000	127.00		minimum	12.125*	307.98*
	C, nominal	1.750	44.45		C, nominal	4.875	123.83
	maximum	2.000*	50.80*		maximum	4.875	123.83
	minimum	1.750	44.45		minimum	4.625*	117.48*
	Lateral runout,[7] maximum	0.570	1.45		Lateral runout,[7] maximum	0.140	3.56
400 feet[6] (122 meters)	D, nominal	7.000	177.80	1600 feet (488 meters)	D, nominal	13.750	349.25
	maximum	7.031	178.59		maximum	14.000*	355.60*
	minimum	7.000	177.80		minimum	13.750	349.25
	C, nominal	2.500	63.50		C, nominal	4.875	123.83
	maximum	2.500	63.50		maximum	4.875	123.83
	minimum	1.750*	44.45*		minimum	4.625*	117.48*
	Lateral runout,[7] maximum	0.080	2.03		Lateral runout,[7] maximum	0.160	4.06
800 feet (244 meters)	D, nominal	10.500	266.70	2000 feet (610 meters)	D, nominal	15.000	381.00
	maximum	10.531	267.49		maximum	15.031	381.79
	minimum	10.500	266.70		minimum	15.000	381.00
	C, nominal	4.875	123.83		C, nominal	4.625	117.48
	maximum	4.875	123.83		maximum	4.875	123.83
	minimum	4.500*	114.30*		minimum	4.625	117.48
	Lateral runout,[7] maximum	0.120	3.05		Lateral runout,[7] maximum	0.171	4.34

*When new reels are designed or when new tools are made for present reels, the cores and flanges should be made to conform, as closely as practicable, to the nominal values in the above table. It is hoped that in some future revision of this standard the asterisked values may be omitted.

Note 1: The outer surfaces of the flanges shall be flat out to a diameter of at least 1.250 inches.

Note 2: Rivets or other fastening members shall not extend beyond the outside surfaces of the flanges more than 1/32 inch (0.79 millimeter) and shall not extend beyond the over-all thickness indicated by dimension S.

Note 3: Except at embossings, rolled edges, and rounded corners, the limits shown here shall not be exceeded at the periphery of the flanges, nor at any other distance from the center of the reel.

Note 4: If spring fingers are used to engage the edges of the film, dimension W shall be measured between the fingers when they are pressed outward to the limit of their operating range.

Note 5: This concentricity is with respect to the center line of the hole for the spindles.

Note 6: This reel should not be used as a take-up reel on a sound projector unless there is special provision to keep the take-up tension within the desirable range of 1½ to 5 ounces.

Note 7: Lateral runout is the maximum excursion of any point on the flange from the intended plane of rotation of that point when the reel is rotated on an accurate, tightly fitted shaft.

Appendix

(This Appendix is not a part of the American Standard for 16-Millimeter Motion Picture Projection Reels, PH22.11-1952.)

Dimensions A and B were chosen to give sufficient clearance between the reels and the largest spindles normally used on 16-millimeter projectors. While some users prefer a square hole in both flanges for laboratory work, it is recommended that such reels be obtained on special order. If both flanges have square holes, and if the respective sides of the squares are parallel, the reel will not be suitable for use on some spindles. This is true if the spindle has a shoulder against which the outer flange is stopped for lateral positioning of the reel. But the objection does not apply if the two squares are oriented so that their respective sides are at an angle.

For regular projection, however, a reel with a round hole in one flange is generally preferred. With it the projectionist can tell at a glance whether or not the film needs rewinding. Furthermore, this type of reel helps the projectionist place the film correctly on the projector and thread it so that the picture is properly oriented with respect to rights and lefts.

The nominal value for W was chosen to provide proper lateral clearance for the film, which has a maximum width of 0.630 inch. Yet the channel is narrow enough so that the film cannot wander laterally too much as it is coiled; if the channel is too wide, it is likely to cause loose winding and excessively large rolls. The tolerances for W vary. At the core they are least because it is possible to control the distance fairly easily in that zone. At the holes for the spindles they are somewhat larger to allow for slight buckling of the flanges between the core and the holes. At the periphery the tolerances are still greater because it is difficult to maintain the distance with such accuracy.

Minimum and maximum values for T, the thickness of the flanges, were chosen to permit the use of various materials.

The opening in the corner of the square hole, to which dimensions U and V apply, is provided for the spindles of 35-millimeter rewinds, which are used in some laboratories.

D, the outside diameter of the flanges, was made as large as permitted by past practice in the design of projectors, containers for the reels, rewinds, and similar equipment. This was done so that the values of C could be made as great as possible. Then there is less variation, throughout the projection of a roll, in the tension to which the film is subjected by the take-up mechanism, especially if a constant-torque device is used. Thus it is necessary to keep the ratio of flange diameter to core diameter as small as possible, and also to eliminate as many small cores as possible. For the cores, rather widely separated limits (not intended to be manufacturing tolerances) are given in order to permit the use of current reels that are known to give satisfactory results.

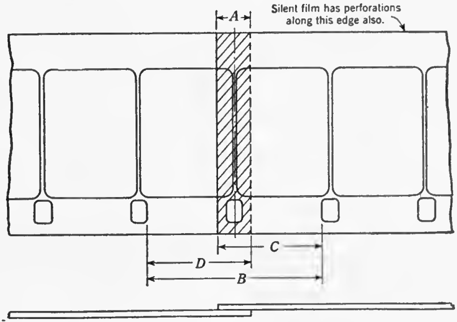
American Standard

Splices for 16-Millimeter Motion Picture Films for Projection

ASA
Reg. U. S. Pat. Off.
PH22.24-1952
Revision of
Z22.24-1941,
Z22.25-1941, and
Z52.20-1944
*UDC 778.55

Scope

Splices made in accordance with this standard are primarily for use with films intended for actual projection, such as release prints and reversal films. It is not intended that this standard be prejudicial to the use of diagonal-type splicers, nor to the use of narrower splices for professional purposes. For negatives and other laboratory films, narrower splices, sometimes with one edge on the frameline, frequently are used.



Dimension	Inches	Millimeters
A	0.100 +0.000 −0.005	2.54 +0.00 −0.13
B	0.548 +0.001 −0.001	13.920 +0.025 −0.025
C	0.324 +0.000 −0.003	8.23 +0.00 −0.08
D	0.324 +0.000 −0.003	8.23 +0.00 −0.08

Note 1: In the plan view, the splice is arranged with the perforations at the bottom in order to show them as they appear on most splicers. The splice may be made with the film turned through an angle of 180 degrees, or any other angle, but, of course, the emulsion surface should always be up. It is customary to scrape the top (emulsion) surface of the left-hand film and to cement this scraped area to the bottom (base) surface of the right-hand film. *(Continued)*

Approved April 30, 1952, by the American Standards Association, Incorporated
Sponsor: Society of Motion Picture and Television Engineers

*Universal Decimal Classification

American Standard **Splices for 16-Millimeter Motion Picture Films for Projection**	ASA Reg. U. S. Pat. Off. **PH22.24-1952**

Note 2: Dimension A is given a negative, but no positive, tolerance because narrower splices are less conspicuous on the screen and are less likely to affect the normal curvature of the film as it follows the bends in its path through cine-machinery.

Note 3: Dimension B controls the longitudinal registration of the two films being spliced. It is measured to the perforations that are most commonly used for registration on splicing blocks, and to the nearer edges of these perforations because they are edges that are generally used for the registration. This dimension is made the same as in the American Standard Splices for 8-Millimeter Motion Picture Films, PH22.77-1952, because many splicers are designed to accept either 16- or 8-mm film.

The nominal value of the B dimension was made 0.548 inch instead of the usual 0.550 (for unshrunk film) because the films being spliced are always shrunk to some extent. The 0.548 figure corresponds to a shrinkage of 0.36 percent, while the 0.549 and 0.547 values, permitted by the tolerances, correspond to 0.18 percent and 0.55 percent, respectively. Thus, the tolerances include the range of shrinkage ordinarily encountered when film is being spliced.

Note 4: Dimensions C and D were chosen to give a straight 0.100-inch splice that is symmetrical about the included perforation (and, therefore, the frame-line) when the film is shrunk 0.36 percent. (See Note 3.)

Note 5: The width of the film at the splice shall not exceed 0.630 inch. If the film has been widened during scraping, the extra width shall be removed.

Note 6: The overlapping perforations of the two films shall not be offset laterally more than 0.002 inch.

Note 7: At the splice, the edges of the two spliced films shall not be offset laterally more than 0.002 inch, unless a difference in the lateral shrinkages of the two strips makes it impossible to maintain that tolerance. Shoulders formed by such misalignment shall be beveled after the cement has dried.

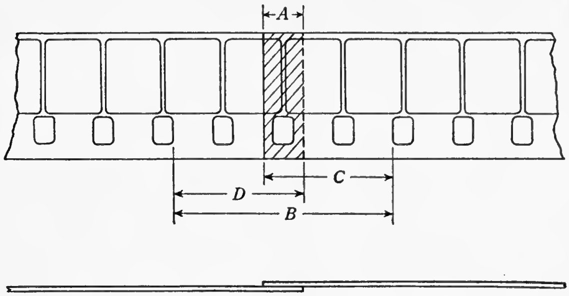
Note 8: In the plan view, the angle between the respective edges of the spliced films shall be 180 degrees, plus or minus 40 minutes. Thus, the spliced film shall be aligned to the extent that when one portion of the film is placed against a straight edge, the other portion will not deviate more than 0.006 inch (approximately the thickness of the film) in 6 inches.

Note 9: In order to prevent the appearance of a white line on the screen, the scraped area shall be 0.001 to 0.003 inch narrower than the area covered by the overlapping film. The presence of this narrow uncemented area will not shorten the life of the splice.

American Standard
Splices for 8-Millimeter Motion Picture Films

ASA
Reg. U. S. Pat. Off.
PH22.77-1952

*UDC 778.55



Dimension	Inches	Millimeters
A	0.100 $^{+0.000}_{-0.005}$	2.54 $^{+0.00}_{-0.13}$
B	0.548 $^{+0.001}_{-0.001}$	13.920 $^{+0.025}_{-0.025}$
C	0.324 $^{+0.000}_{-0.003}$	8.23 $^{+0.00}_{-0.08}$
D	0.324 $^{+0.000}_{-0.003}$	8.23 $^{+0.00}_{-0.08}$

Note 1: In the plan view, the splice is arranged with the perforations at the bottom in order to show them as they appear on most splicers. The splice may be made with the film turned through an angle of 180 degrees, or any other angle, but, of course, the emulsion surface should always be up. It is customary to scrape the top (emulsion) surface of the left-hand film and to cement this scraped area to the bottom (base) surface of the right-hand film.

Note 2: Dimension A is given a negative, but no positive, tolerance because narrower splices are less conspicuous on the screen and are less likely to affect the normal curvature of the film as it follows the bends in its path through cine-machinery.

(Continued)

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*Universal Decimal Classification

American Standard

Splices for 8-Millimeter Motion Picture Films

ASA
Reg. U. S. Pat. Off.

PH22.77-1952

Note 3: Dimension B controls the longitudinal registration of the two films being spliced. It is measured to the perforations that are most commonly used for registration on splicing blocks, and to the nearer edges of these perforations because they are edges that are generally used for the registration. This dimension is made the same as in the American Standard Splices for 16-Millimeter Motion Picture Films for Projection, PH22.24-1952, because many splicers are designed to accept either 8- or 16-mm film.

The nominal value of the B dimension was made 0.548 inch instead of the usual 0.550 (for unshrunk film) because the films being spliced are always shrunk to some extent. The 0.548 figure corresponds to a shrinkage of 0.36 percent, while the 0.549 and 0.547 values, permitted by the tolerances, correspond to 0.18 percent and 0.55 percent, respectively. Thus, the tolerances include the range of shrinkage ordinarily encountered when film is being spliced.

Note 4: Dimensions C and D were chosen to give a 0.100-inch splice that is symmetrical about the included perforation (and, therefore, the frameline) when the film is shrunk 0.36 percent. (See Note 3.)

Note 5: The width of the film at the splice shall not exceed 0.317 inch. If the film has been widened during scraping, the extra width shall be removed.

Note 6: The overlapping perforations of the two films shall not be offset laterally more than 0.002 inch.

Note 7: At the splice, the edges of the two spliced films shall not be offset laterally more than 0.002 inch, unless a difference in the lateral shrinkages of the two strips makes it impossible to maintain that tolerance. Shoulders formed by such misalignment shall be beveled after the cement has dried.

Note 8: In the plan view, the angle between the respective edges of the spliced films shall be 180 degrees, plus or minus 40 minutes. Thus, the spliced film shall be aligned to the extent that when one portion of the film is placed against a straight edge, the other portion will not deviate more than 0.006 inch (approximately the thickness of the film) in 6 inches.

Note 9: In order to prevent the appearance of a white line on the screen, the scraped area shall be 0.001 to 0.003 inch narrower than the area covered by the overlapping film. The presence of this narrow uncemented area will not shorten the life of the splice.

71st Semiannual Convention

The several sources and aspects of the Society's overall interest were reflected from the opening Monday noon Get-together Luncheon right on through the eleven-session technical program organized by Program Chairman Geo. W. Colburn and held at The Drake in Chicago on April 21–25. Besides sessions arranged by topics such as television, screens, high-speed photography and usual motion picture subjects, one session was labeled as to source — the armed forces production session. The complete roster of the authors and their papers is given on later pages of this *Journal*.

Excerpted below are the convention introductory remarks by President Peter Mole, who also introduced the principal speaker, Dr. W. R. G. Baker, General Electric Vice-President and General Manager of its Electronics Div., Syracuse, N.Y. Mr. Mole noted that Dr. Baker, known for his pioneering in radio and television, has, among his numerous contributions to American industry, service as a key figure in the coordination of technical developments through the work of industrial and technical societies. He has been President of the I.R.E. and R.T.M.A. His speech on the work of the National Television System Committee is given in part below.

President Mole also welcomed Jimmy Frank as one who needs no introduction to old timers of the Society. He spoke as Deputy Director of the Motion Picture and Photographic Products Div. of the National Production Authority and his speech is excerpted below.

A lighter part of the luncheon program was the appearance of Leon Ames, motion picture actor then starring in Chicago's long-run stage performance of *The Moon Is Blue*. He came to the luncheon through the kindly offices of George Colburn to assure engineers in a whimsical fashion that even actors and engineers can get along more and more agreeably as they increase their appreciation of the other fellows' side of the business.

Get-Together Luncheon Remarks by President Mole

It is encouraging to note that an interest in engineering is developing quite generally among motion picture people who have not had technical training or experience. Evidence appears in many places — in plans of motion picture interests to appear before the Federal Communications Commission in the matter of theater television — in current efforts to produce stereoscopic motion pictures for theater release — in the first steps toward extending the field of view of theater patrons through changes in screen design or illumination of the surrounding area — and in widespread introduction of new or enlarged facilities for release printing in color. Another significant indication of the new interest in engineering is the all-industry research program proposed last winter by Dr. L. A. du Bridge, President of the California Institute of Technology.

The motion picture industry need not wait for the institution of an extensive research program, however, before further progress can be made along technical lines. A great deal can be done on a small scale. Each manufacturer of equipment, each producer of motion pictures, and each exhibitor who possesses an engineering or technical department can conduct his own development program.

Young engineers can be hired to bring new blood into an old organization, and promising students can be employed during summer vacations. Many students would be glad to take temporary jobs on a trial basis, with the chance for full-time work after graduation. The more apt students might well be given scholarships and encouraged to pursue a course of study relating directly to a particular industrial problem.

Other steps which can be taken toward the same goal include the placing of development contracts with commercial research organizations.

Our Society serves to coordinate those activities of the industry that relate directly to technical standardization and interchangeability. It also conducts studies

designed to assist entire branches of the industry in learning more about their technical operations. Through the *Journal*, published twelve times each year, it provides a valuable source of technical data that helps in the orientation of engineers just entering the field.

These are the means for steady substantial technical growth, and they are available at nominal cost.

By working in concert with each other and with the men who manage the business of making and using motion pictures for various purposes, our members provide an effective and valuable service. For that reason the Society deserves the continued active support of all related commercial interests, as well as its members.

Given such backing, the Society will continue to function as a fountainhead of the technical progress which underlies both service and profitable operation in all branches of the motion picture and television industries.

Excerpts From Address by Dr. W. R. G. Baker

Authorized by the Radio-Television Manufacturers Association, the present National Television System Committee is a committee whose members are representatives of organizations broadly interested in and experienced in the television field, or of technical organizations vitally interested in research and development of television, as well as qualified individuals not associated with any organization, association or company.

The Committee is charged with the task of assembling technical data on: (1) the allocation of channels in the ultra-high-frequency band; (2) procedures enabling the FCC to lift the "freeze" on very-high-frequency allocation; and (3) basic standards for the development of a commercially practicable system of color television; and it is directed to undertake such additional work as may be indicated to provide more adequate television service to the American public.

Various projects within the framework of the charter of the NTSC are assigned to individual members of the Committee or to technical panels named by the chairman with the concurrence of the vice-chairmen. The members of the panels are drawn from any company, association or organization regardless of affiliation. The only requirement for membership on any panel is recognized skill, interest and ability in the assigned project. When each panel completes an assigned project, it submits a report stating both majority and minority opinions to the NTSC.

The frequency spectrum and particularly that portion utilized in communication, is one of our national resources, as much a national resource as are the supplies and reserves of crude oil or forests or mineral ores. Although the frequency spectrum transcends all geographical or political boundaries, most of the spectrum is of its greatest value within such borders, and therefore can be considered a physical asset of political entity.

Misuse or inefficient use of the spectrum is as great a physical loss as destruction of our other natural resources. And efficient use of the spectrum is difficult to achieve for these reasons:

(1) The spectrum has physical limits. At any one period in the development of the electronic art, only a stated amount of information can occupy the spectrum.

(2) The "lock and key" element is present in every use of the spectrum. Receiving equipment is useless without transmitting equipment and vice versa. Development of the two elements must proceed simultaneously.

(3) Economics often prove a greater factor in governing rate of development than does scientific knowledge. The cost of moving a service from one section of the spectrum to another may be so great that it is not, at any stated time, in the public interest to make the move even though it would result in efficiencies throughout the entire spectrum.

Although the Federal Communications Commission maintains its own group of technical experts, the competition inherent in a private enterprise and within industry — and I'm sure you all will agree there is no industry more competitive than the electronics industry — would normally be an obstacle to the FCC

obtaining free access to the latest technical information, and particularly information concerning promising avenues of developmental research.

It is also true that in a competitive business you may have persons or concerns who will fight more vigorously for acceptance of an idea, or a development, than will others with equally acceptable ideas or developments. To reach a point closest to a correct evaluation of ideas or developments, to make such information available to the FCC, to help focus research and development toward the quickest solution of a problem, an organization like the National Television System Committee is necessary.

In 1939 the FCC held a hearing to determine whether it was practical to establish standards for monochrome television. This hearing developed two important facts. First, monochrome television had been developed to a point where from the technical viewpoint, commercialization was a distinct possibility. Second, at the hearing the industry had demonstrated beyond a doubt that about the only agreement on standards that could be expected was an agreement to disagree.

As of January 15, 1940, the status of the necessary standards for the establishment of a national system of television was substantially as follows: There was no great difference of opinion in the industry with respect to the frequency assignments for television. However, it was clearly apparent that in the industry there was wide divergence of opinion concerning the system standards. Furthermore, there was every indication that unless and until these divergent ideas could be reconciled, progress toward a national system of television was practically at a standstill.

Fourteen months later, after the formation of the first NTSC, full commercial operation of monochrome television began with the approval of the Commission. In this short time the plan for the National Television System Committee had been formulated, the committee assembled, its meetings held, its minutes recorded, technical reports compiled and its final report delivered to the Commission. When the Committee's recommendations were made to the Commission, the complexion of the industry had changed from a discord of counterclaims to a concord of expert opinion which persuaded the Commission to acknowledge its value and to proclaim the art open to the public.

From the time of the first NTSC, color television has been under serious consideration by the engineers of the industry.

You are all familiar with the recent hearing on color television. If one reads the transcripts of the monochrome television hearing preceding the establishment of the first NTSC and the recent color television hearing, certain facts are quite evident:

(1) At the time of the monochrome hearing several experimental transmitters were in use providing television programs to several hundred receivers. There was little if any question on the ability of the industry to provide a commercial monochrome television service from the viewpoint of providing products in the form of transmitters, studio equipment, receivers and certain specialized tubes. The public had ample opportunity to see television and accepted it enthusiastically.

(2) The industry was not faced with any prior obligation such as obsolescence of equipment in the hands of the public. No television receivers had been sold, hence the public had made no investment.

(3) While there was no disagreement within the industry as to the availability of the tools necessary to establish a commercial monochrome television service, there were wide differences of opinion as to the standards on which such service should be based.

The comparable situation with respect to color television was as follows:

(1) There was no extensive experimental broadcasting of color television as was the case with monochrome television. There were very few color television receivers viewing such color television broadcasting. A real question existed as to the ability of the industry to produce color television equipment capable of rendering a commercial service. While there had been some exposure of color television programs to the public, it was not in any sense as extensive as was the case with monochrome.

(2) The public was confronted with the possibility of the investment it had

made in monochrome television receivers being obsoleted. There had been some experience in the case of FM with the mass obsolescence of products in the hands of consumers and it was difficult to look with favor on a repetition of this problem. The entire problem can be summed up in the idea of compatibility with which you are familiar.

(3) There was certainly real and justifiable concern as to the availability of the tools necessary to commercialize color television.

Right or wrong, and personally I think it was right, many engineers felt that insufficient foundation had been laid to warrant selection of a system of color television.

With these facts in mind, it seemed to the RTMA Television Committee that one possibility of resolving the problem was through the formation of a second NTSC. Such action was recommended to the Board of Directors of RTMA and approved.

The NTSC proceeded under its assigned charter but in the late fall of 1950 it became clear that because of the many advances and new proposals relating to color television systems and components, it would be necessary to have an up-to-date appraisal of the state of the art. A special, or ad hoc, committee of the NTSC was established. Some months later, the committee proposed a reorganization of the NTSC to permit a more direct study on the problems and outlined the broad framework of a new standards for color television achieved by combining the best elements of the furthest advances of existing proposals.

The NTSC accepted the ad hoc committee report because it stated a philosophy without specifying details of a color television system. The NTSC technical panels were revised and the work of building around the framework established by the ad hoc committee has gone forward.

The value of the NTSC, to my mind, has been the fact that, in almost every case, when the technical panels sat down to work, those forces which could have distorted their vision, their deliberations, were left outside the door. Engineers and scientists tend to forget their pride in their own idea or research when they are joined in a conference with many others whose technical competence they respect.

Excerpts From Address by James Frank, Jr.

The National Production Authority, under the authority of the Defense Production Act of 1950, created in the Department of Commerce in September 1950, and the Defense Production Administration established in January 1951 were set up to accomplish certain basic objectives. The most important of these were:

(1) To set up programs and procedures which would permit the most efficient rapid progress of the defense mobilization program and, in the event of the necessity of full mobilization, to meet the requirements of the Department of Defense and the Atomic Energy Commission. This objective has been fully met by this time, with emphasis on the fact that a full Controlled Materials Plan has been put into satisfactory operation.

(2) To get the defense mobilization under way so that the military could, as quickly as possible, build up its supply of necessary material.

(3) To the extent possible, to permit the accumulation of critical materials, for which we depend on imports to a large extent, as a stockpile in the event of full mobilization.

(4) To encourage and effect expansion of facilities for the production of raw materials and military products to meet the requirements of the Department of Defense and the Atomic Energy Commission in the event of full mobilization.

(5) To carry out all of the above objectives without handicapping civilian industry to any greater extent than need be.

Let us get straightened out on some confusing issues. The defense mobilization program has been increased, not decreased, and the 1953 Budget before Congress now calls for an increase from 3,500,000 men and women in the armed services to 3,700,000 and, in the case of the Air Force, from 95 Wings under the present program to 143 Wings. The new program also calls for certain increases in the Army, Navy and Marine Corps. As a result of

world conditions at this time, our military and civilian authorities believe that our rearmament goals should be set somewhat higher. At the same time, however, the rearmament program has in fact been lengthened from approximately three years to approximately four years, but we are now talking about the new increased program.

There has been some cancellation of military contracts but not to as wide an extent as some are led to believe by the newspapers. One of the reasons for this is that the armed services at first placed some contracts for military goods for the increased program in the belief that that program would be achieved in three years, rather than four years. When the term of four years was decided on, they cancelled some contracts. Another explanation is that the design of new machine tools, substitution of materials, etc., has required some changes in planning. Furthermore, constantly improving design of weapons calls for the altering of contracts and cutting down or ceasing production of the old types of products.

The amount of material that was returned to DPA by the Department of Defense for the second quarter can be misleading. 25,000,000 pounds of copper returned is 12,500 tons, or less than one-half of one per cent of our annual consumption of copper.

The easing of material shortages is explained by the above minor return of material and the fact that there has been a considerable increase in our production of certain basic metals, as well as electric power, petroleum and the like. For instance, steel production has been increased from 100,000,000 tons a year, pre-Korea, to 109,000,000 tons, and will continue to rise to 120,000,000 tons per year. Aluminum production has increased by 150,000 tons and eventually will be double pre-Korea. Furthermore, the operation of the Controlled Materials Plan has really begun to work and manufacturers are able to book orders with mills when they get such allotments. That has minimized scare buying and has encouraged reduction of large inventories.

However, there are now two serious problems with respect to controlled materials. All of the copper products, as well as nickel-bearing stainless steel, are and will continue for some time, to be in tight supply.

The constant flow of civilian products during the past year, despite material shortages, is a tribute to the ingenuity of engineers such as those represented by this Society. They have affected remarkable conservation in the use of critical materials to permit maximum production of end products. However, at this time, certain vigorous efforts are required to minimize the use of all of the forms of copper and of nickel-bearing stainless steel.

There is definite evidence that the officials of DPA and NPA are anxious to lift controls the moment that they can do so safely. This is evident with respect to rubber, lead, non-nickel-bearing stainless steel, and others. However, we still must travel a long road before we reach the desired stage of decontrol. In the third quarter, direct defense needs will take 18% of all our carbon steel, 35% of our alloy steel, 19% of our copper foundry products, 27% of our copper wire mill products, 46% of our copper brass mill products, and 43% of our aluminum. To some extent, moreover, expanding production of materials in the months ahead will be counterbalanced by expanding military needs.

It is our feeling that until such direct defense needs of any controlled material reaches the level where they are not in excess of 20 or 25% of total supply, they should not be completely decontrolled. It is hoped that certain forms of carbon steel and aluminum may be decontrolled early next year.

Some people have asked whether we are not taking a terrific risk in extending the Defense Mobilization Program from three to four years. Unquestionably there is a calculated risk, based on current world conditions, but it is felt that it would be unwise to break ourselves or cripple our economy with a mad rush in rearmament and then find we had a mountain of weapons rapidly becoming obsolescent. We are gathering strength in an orderly fashion, which will keep us stronger over a longer period of time than if we rushed now into all-out mobilization.

One of the serious problems is military design changes. Such design changes mean improvements. Improvements mean a finer fighting machine. For our

members of the armed forces they mean more offensive power, more defensive protection. It is a hard decision to have to make between freezing designs and pouring out the stuff, or allowing more design changes and slowing up production. If we thought the Soviets were going to attack tomorrow, of course we would freeze and pour it out, but if they did not attack, we would have spent a lot of money, chewed up a lot of much-needed copper and aluminum, and have on our hands a mountain of obsolescent weapons. By allowing for a reasonable number of design changes: we get better weapons in the long run; we use up less material; and we save some money for the bedeviled taxpayer.

Since the establishment of the National Production Authority, a year and a half ago, a strong organization has been developed, basic regulations and controls have been created and improved as a result of close cooperation with industry, the Controlled Materials Plan has been re-created, and is now working effectively, and a system of priorities has been brought into existence. While many difficulties have been encountered and mistakes made, the job has been done. Military production, industrial expansion, and all defense supporting programs are moving ahead at rapid rates. Moreover, the organization, control techniques, and experience, all of which represent tremendous resources, equal to the weapons of war, will stand us in good stead should the necessity for their increased use arise. While all of us hope that this will not be the case we must continue to emphasize the importance of preparedness.

"Chicago" was a very smoothly functioning Convention, due to the cooperative and coordinated efforts of the many Chicago people who worked hard: George Colburn for the Papers Program and the Luncheon and Banquet and C. E. Heppberger for the overall of Local Arrangements. Supporting George Colburn on the procuring of papers were Papers Committee Chairman Ed Seeley and Vice-Chairmen J. E. Aiken, F. G. Albin, G. G. Graham, R. O. Painter (for High-Speed Photography), W. H. Rivers and R. T. Van Niman, with some assists by Editorial Vice-President John G. Frayne.

To get the folks registered and oriented is a real job at each convention and, though high on the list of the many cares of the Society's Convention Vice-President Bill Kunzmann who is always on deck, registration is a major operation — at Chicago well done under Chairman Jim Wassell with a strong assist by Reid Ray and help by Steve Hunter, Ken Mason, Charles Nesbitt, Jack Powers and Paul Ireland.

Public address and recording were the bailiwick of Robert P. Burns who put and kept the Society's equipment completely under control to record a goodly lot of convention discussion, while listening with one ear to the Sound Dept. of Balaban & Katz where he is Director.

I. F. Jacobsen, Projection Supervisor for Balaban & Katz, kept steady control of the convention projection, with E. W. D'Arcy initially responsible for 16mm projection plans. In charge of rounding up the motion picture shorts was L. E. Weber, assisted by R. J. Sherry.

An assist for television papers planning was given by Wm. C. Eddy. Chairman for hotel and transportation arrangements was Wm. C. De Vry. Membership promotion activities were headed by Col. S. R. Todd who is the Membership Committee's Vice-Chairman in Chicago. Ray Gallo, Chairman of the Membership Committee, was on hand with active meetings and planning in the latter part of the week.

Publicity was handled on the spot by Len Bidwell who kept a solid volume of information going out through channels to trade and general press, with some nice, effective help from Mrs. Bidwell. Co-hostesses for the Ladies' Program were Mrs. C. E. Heppberger and Mrs. Geo. W. Colburn who presented a highly praised program of which one highlight was a luncheon production of Miniature Grand Opera by Fredrik A. Chramer who presented *Madame Butterfly*, with realistic puppets and with music recorded by the Metropolitan Opera Company.

Committee meetings continued to be an

important part of the week's activities. There were eight engineering committee meetings which have been covered in the May issue of the *Journal* under the usual column "Engineering Activities." In addition to the Membership Committee Meeting mentioned above, there was a papers and editorial meeting under the aegis of Ed Seeley and John Frayne, chiefly to pass on to Joe Aiken the main mantle for the next convention — of which much in detail in the next *Journal.*

Engineering Activities

Color As noted in the February 1952 *Journal*, the four-year limitation term of office required appointment of a new chairman to the Color Committee. To this end, Fred Bowditch, Engineering Vice-President, recently appointed J. P. Weiss of Du Pont to fill the post.

Television Studio Lighting The committee met on June 4, 1952, and further discussed specifications for incident light and brightness meters, amending the former by placing a 10% tolerance on the deviation from a cosine response. Word was received from Photo Research Corp. that they are producing a brightness meter which meets the committee specifications and the committee is eagerly looking forward to an opportunity to study and test it.

A subcommittee on terminology under the chairmanship of Hank Gurin was formed to start activity on this vital project.

Glossary Glossary activity in the past has depended primarily on the activity of individuals and engineering committees whose chief interest lay in specialized subjects and projects. This has produced much useful material but not the industry-wide layman type of glossary that is required. The Engineering Vice-President has therefore established a committee charged solely with the responsibility of bringing out a useful glossary. Bill Offenhauser has accepted the chairmanship of this committee and is looking about for competent and eager members. The Committee will first take inventory of past work and then draw up its plan of attack. It will correlate its activities with similar activities of other societies and call upon all branches of industry and all SMPTE engineering committees for any required assistance. Those interested in participating in the work of this new committee are asked to so advise Bill Offenhauser or Hank Kogel at Society Headquarters.

Television Film Equipment The main order of business at the May 27, 1952, committee meeting was the discussion of the film recording and reproduction dimensions. The committee has been attempting to reach agreement on proposed standards with no success as yet. Differences have cropped up both on the East and West Coasts. One claims an excessive loss of material in the kinerecording process; the other is seeking to increase the size of the reproduced or scanned area. The detailed discussion of these problems is contained in SMPTE 461, a copy of which is available upon request.

In addition, agreement was reached on proposals regarding dimensions of slides and opaques which must now go to a letter ballot of the full committee.

ISO/TC 36 The Technical Committee on Cinematography of the International Organization for Standardization met as scheduled on June 9, rolled up its sleeves and proceeded to do a very workmanlike job. After establishing the order of importance of the various items on the agenda and extending the meeting to three days instead of the two originally planned, the committee broke up into informal work groups for round-table discussion. The areas of agreement and disagreement were thoroughly canvassed (to the degree that time permitted) with a considerable measure of success. The delegates were agreed that an excellent foundation had been laid for international standards activity which could now be fruitfully pursued through correspondence. A more detailed report will be made available to the Society at a later date.—*Henry Kogel*, Staff Engineer

Current Literature

The Editors present for convenient reference a list of articles dealing with subjects cognate to motion picture engineering published in a number of selected journals. Photostatic or microfilm copies of articles in magazines that are available may be obtained from The Library of Congress, Washington, D.C., or from the New York Public Library, New York, N.Y., at prevailing rates.

American Cinematographer

vol. 33, Feb. 1952

Technicolor Cameras Now Ride the RO Crane (p. 65) *A. Rowan*

Stereoscopic Movies With Any 16mm Camera (p. 72) *J. Forbes*

vol. 33, Mar. 1952

"The Wild North" Introduces MGM's New Ansco Color Process (p. 106) *A. Rowan*

Stereoscopic Motion Pictures, Pt. II (p. 110) *J. A. Norling*

New Resolving Power Test Chart (p. 111)

Bell & Howell Introduces 16mm Magnetic Recorder-Projector (p. 112) *E. C. Hajduk*

British Kinematography

vol. 20, Mar. 1952

A Projector-Family Programme — The FP. 7 Projector — (p. 66) *J. J. Kotte*

Filming Radar (p. 77) *J. R. F. Stewart*

Exposure for Colour (p. 83) *J. H. R. Coote*

International Projectionist

vol. 27, Feb. 1952

Illuminated Screen Surround? No; Rounded Masking Corners? Yes. (p. 18) *R. A. Mitchell*

vol. 27, Mar. 1952

Better Film Care Improves Entertainment, Pt. I (p. 7)

LaVezzi's Newly-Designed Intermittent Movement (p. 16)

vol. 27, April 1952

What's New in Projection Screens (p. 5)

Three-dimensional Projection in Europe (p. 9)

Better Film Care Improves Entertainment, Pt. II (p. 10)

Kino-Technik

no. 3, 1952

Storschallgeber rings um das Mikrophon (p. 56) *E. Leistner*

Die internationale Spielfilm — Produktion aus zwanzig Jahren (p. 50)

Schmalfilm — Theater maschine "Leitz G 1" in drei Typen (p. 58) *E. May*

Der Farbfilm im Atelier, in der Kopieranstalt und im Theater (p. 63) *W. Behrendt*

16mm-Tonfilmprojektoren auf dem deutschen Mark(p. 66)

no. 4, April 1952

Ein neues Kamerasystem für Stereoaufnahmen (p. 74) *H. Lüscher*

Welche Anforderungen stellt das Fernsehen an den Rohfilm? (p. 80)

Eine leistungsfähige 16mm-Bilton-Kamera (p. 84)

Proceedings of the I.R.E.

vol. 40, Feb. 1952

Improvements in Image Iconoscopes by Pulsed Biasing the Storage Surface (p. 146) *R. Theile and F. H. Townsend*

Radio & Television News

vol. 47, April 1952

(Radio-Electronic Engineering Section)

High Speed Image Converter (p. 12) *H. Weil*

RCA Review

vol. 13, Mar. 1952

Performance of the Vidicon, a Small Developmental Television Camera Tube (p. 3) *B. H. Vine, R. B. Janes and F. S. Smith*

The RCA Color Television Camera Chain (p. 11) *J. D. Spradlin*

Image Orthicon Color Television Camera Optical System (p. 27) *L. T. Sachtleben, D. J. Parker, G. L. Allee and E. Kornstein.*

The NBC New York Color Television Field Test Studio (p. 107) *J. R. DeBaun, R. A. Monfort and A. A. Walsh*

Tele-Tech

vol. 11, April 1952

A New All-Purpose Television Camera (p. 38) *A. Reisz*

Tele-Vision Engineering

vol. 3, April 1952

Magnetic Sound and Negative Picture Transmission (p. 10) *R. Conner*

New Members

The following members have been added to the Society's rolls since those last published. The designations of grades are the same as those used in the 1952 MEMBERSHIP DIRECTORY.

Honorary (**H**) Fellow (**F**) Active (**M**) Associate (**A**) Student (**S**)

Abernathy, Lloyd B., Director of Photography, Fotovox, Inc., 286 Monroe Ave., Memphis, Tenn. (**A**)

Alsworth, Charles W., Jr., Chief, Cinematography, Edwards Air Force Base. **Mail:** Box 124, Edwards, Calif. (**A**)

Andresen, Warren, Field, Studio Technical Director, KGO-TV. **Mail:** 2420 Hilgard Ave., Berkeley 9, Calif. (**A**)

Aselstyne, John G., General Manager, Benson-Wilcox Electric Co., 188 King St., London, Ontario, Canada. (**A**)

Baran, Paul, Engineer, Audio-Video Products Co., 730 Fifth Ave., New York, N.Y. (**A**)

Bates, Reginald, Engineer, John M. Wall, Inc. **Mail:** 718 Irving Ave., Syracuse 10, N.Y. (**M**)

Bazaar, Walter T., Chemist, Signal Corps Photo Center. **Mail:** 20–17—19 St., Long Island City 5, N.Y. (**A**)

Callen, Robert J., Audio Engineer, Glen Glenn Sound Co. **Mail:** 3467 Adina Dr., Hollywood 28, Calif. (**M**)

Capano, Dominick J., Stock Manager, S.O.S. Cinema Supply Corp. **Mail:** 94 Knox Pl., Staten Island 14, N.Y (**M**)

Coston, Melvin L., Senior Photographer, Humble Oil & Refining Co. **Mail:** 722 W. 42 St., Houston 18, Tex. (**A**)

Eagler, Paul, Process Cameraman. **Mail:** 2142 Prosser Ave., West Los Angeles 25, Calif. (**M**)

Frew, Patricia, University of Southern California. **Mail:** 802 N. Kinglsey Dr., Hollywood 29, Calif. (**S**)

Gardiner, J. H., Television Engineer, National Broadcasting Co. **Mail:** 914 N. Isabel, Glendale 7, Calif. (**A**)

Gately, Frederick, First Cameraman, Mark VII Productions. **Mail:** 522 S. Barrington Ave., Los Angeles. (**M**)

Germain, J. Roger, Television Projectionist, Canadian Broadcasting Corp., Box 6000, Montreal, Canada. (**A**)

Heiland, John G., Chief, Engineering Laboratories, Bell & Howell Co. **Mail:** 1339 Center St., Des Plaines, Ill. (**M**)

Hirasawa, Isao, Chief Engineer, Tokyo Theatre Supply Co., Ltd. **Mail:** No. 86, Takaban-cho, Meguro-ku, Tokyo, Japan. (**A**)

Huhndorff, Ervin P., Chief Engineer, KPRC-TV, Lamar Hotel, Houston, Tex. (**A**)

Kragiel, Henry P., Chemist (Industrial), Stanley Works. **Mail:** 97 Eastwick Rd., New Britain, Conn. (**A**)

Lepage, John L., Electronics Technician, National Research Council. **Mail:** 12 Pankdale Ave., Deep River, Ontario, Canada. (**A**)

Lustberg, Stanley E., Television Cameraman, Radio Belgrand. **Mail:** c/o American Embassy, Buenos Aires, Argentina. (**A**)

Mangan, William J., Film Producer for Television, National Television Guild. **Mail:** 37–45—100 St., Corona 68, N.Y. (**M**)

McInnes, Harold W., Radio Engineer, International Broadcasting Co., Ltd. **Mail:** 6560 East Hastings St., North Burnaby, British Columbia. (**A**)

Merritt, Charles H., Engineering Section, U.S. Dept. of State, 221 W. 57 St., New York 19, N.Y. (**M**)

Mowery, Raymond, Field Engineer, RCA Service Co. **Mail:** 3705 Windom Rd., Brentwood, Md. (**A**)

Ott, John Nash, Jr., President, John Ott Pictures, Inc., 85 Hibbard Rd., Winnetka, Ill. (**M**)

Pesca, Frank, Junior Engineer, Federal Manufacturing & Engineering Corp. **Mail:** 2912—86 St., Brooklyn 23. (**A**)

Quentin, Charles F., Radio Engineer, Cowles Broadcasting Co., KRNT. **Mail:** 1120 Polk Blvd., Des Moines 11, Iowa. (**A**)

Rasmussen, Hans Christian Erik, Chief Sound Engineer, Cia: Cinematografica Vera Cruz, 311, Rua Major Diogo, São Paulo, Brazil. (**A**)

Sharpe, Robert K., Brown University. **Mail:** 90 Crescent Dr., Glencoe, Ill. (**S**)

Sidlo, Thomas C., District Engineer, Lamp Div., General Electric Co. **Mail:** 230 S. Clark St., Rm. 1233, Chicago. (**A**)

Usuf, Mohammad, Engineer, Western Electric Co. (Near East), Karachi, Pakistan. (**A**)

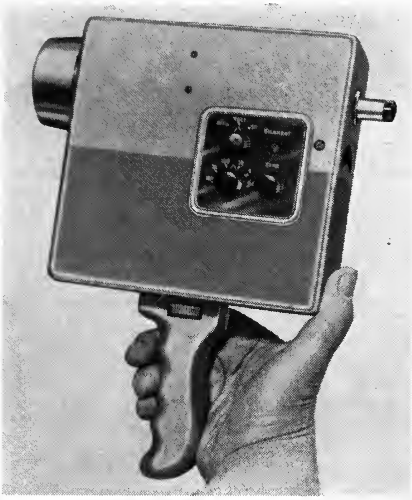
Walker, Alberto W., Territorial Manager, Loew's International Corp., 1540 Broadway, New York, N.Y. (**A**)

CHANGES IN GRADE

Greenfield, J. C., (**A**) to (**M**)
Tickes, Samuel, (**A**) to (**M**)
Wilson, Brown, (**A**) to (**M**)

New Products

Further information about these items can be obtained direct from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of these items does not constitute endorsement of the products.



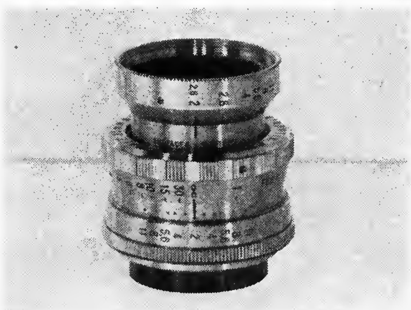
This new Spectra Brightness Spot Meter will soon be available from Photo Research Corp., 127 W. Alameda Ave., Burbank, Calif. It is designed to measure the brightness of a very small area at any distance from 4 ft to infinity, through the use of a vacuum photocell, amplifier and microammeter. All users obtain the same reading of a given area, for the meter is independent of the sensitivity of the observer's eye and requires no matching of brightness.

The size of the area measured is 1°, that is a 1-in. spot at 5 ft, 2-in. spot at 10 ft, etc. The subject to be measured is viewed at considerable magnification through the telescopic sight built into the meter, a circle in the center of the field of view indicating the actual area being measured. The meter is self-contained, having no external power source. It weighs about 5 lb.

To allow handholding the meter and still reading the brightness, a locking-type microammeter is used. The operator pushes a button on the side when the desired area is in the reticule circle and then releases the button again. The meter holds the reading until the button is again depressed.

The sensitivity of the meter is broad, having an overall range from 1 to 1,000,000-ft-L over its five ranges. A logarithmic scale meter is used to accomplish a percentage of accuracy about the same over the entire scale. The photocell is filtered so that its response closely approximates visual response.

Photo Research Corp. has designed the meter with the idea that it will be most useful for measuring brightness from a given position, such as the camera position in cinematography or television, and in measuring screen brightness.



A new 16mm lens series has been announced by the Kinoptik Company of Paris, France, which for several years has had a 35mm series for motion picture and television cameras. Available in C-mounts for standard 16mm motion picture cameras are 20-, 25-, 32-, 50- and 75-mm Kinoptik lenses. They have *T* as well as *f* scales, a new system of equidistant aperture markings, and a six-element design. Shown here is a Kinoptik for 16mm, 1-in., *f*/2 Apochromat in focusing C-mount. Complete descriptions of both the 35mm and 16mm lenses are available from the U.S.A. distributor, Victor Kayfetz, 130 E. 56 St., New York 22, N.Y.

Lantern Slides and How to Make Them is a 37-page reprint booklet of which 26 pp. are from *See and Hear* magazine and written by Mary Esther Brooks of the Bureau of Audio-Visual Aids at Indiana University. In these pages are a wealth of details about techniques, materials and sources, arranged in four chapters and a bibliography. Additional chapters are: (1) "Letter Height and Legibility" by R. A. Sage and reprinted from the *Journal of the Biological Photographic Association;* (2) "Homemade Slides by Photographic Methods" and (3) "Filing Opaque Projection Material" by Harold F. Bernhardt from *The Educational Focus.*

Copies are available, preferably in orders of 50 copies or more, at 20 cents per copy from the Educational Sales Division, Bausch & Lomb Optical Co., 786 St. Paul St., Rochester 2, N.Y.

Back issues of the Journal available: 5 years (1947–51) in perfect condition plus the indexes for 1936–45 and 1946–50 and including the 1949 High-Speed Photography, upon any reasonable offer to Vic Gretzinger, 3547 Suter St., Oakland 19, Calif.

Journals and Transactions available: Of the *Transactions* Nos. 11, 14, 20, 21, 23, 25, 27, 28 and 38; and 22 years of the *Journal* (1930–1951) except for Jan., Feb., Mar. and Apr. of 1934, Jan. and Apr. of 1948, and Feb. 1950; also these extra single copies — Nov. 1930; Jan., Feb., July and Nov. 1931; June 1932; Mar. and Apr. 1933; Dec. 1934; Jan. and May 1935; Oct. 1938; July and Dec. 1940; Oct. 1948 and Jan. 1950. These are available upon any reasonable offer made to: Paul J. Larsen, Assistant to the President, Borg-Warner Corp., 310 So. Michigan Ave., Chicago 4, Ill.

Meetings

72nd Semiannual Convention of the SMPTE, Oct. 6-10, Hotel Statler, Washington, D. C.

Other Societies

National Audio-Visual Association, Convention and Trade Show, Aug. 2–5, Hotel Sherman, Chicago, Ill.

University Film Producers Association, Annual Meeting, Aug. 11–15, Syracuse University, Syracuse, N. Y.

Photographic Society of America, Annual Convention, Aug. 12–16, Hotel New Yorker, New York

American Institute of Electrical Engineers, Pacific General Meeting, Aug. 19–22, Hotel Westward Ho, Phoenix, Ariz.

International Society of Photogrammetry, Conference, Sept. 4–13, Hotel Shoreham, Washington, D.C.

American Standards Association, Third National Standardization Conference, Sept. 8–10, Museum of Science and Industry, Chicago, Ill.

Illuminating Engineering Society, National Technical Conference, Sept. 8–12, Edgewater Beach Hotel, Chicago, Ill.

Biological Photographic Association, Annual Meeting, Sept. 10–12, Hotel New Yorker, New York

National Electronics Conference, Annual Meeting, Sept. 29–Oct. 1, Sherman Hotel, Chicago, Ill.

Optical Society of America, Oct. 9–11, Hotel Statler, Boston, Mass.

American Institute of Electrical Engineers, Fall General Meeting, Oct. 13–17, New Orleans, La.

American Standards Association, Annual Meeting, Nov. 19, Waldorf-Astoria, New York

Papers Presented at the Chicago Convention, April 21-25

By Sessions

MONDAY AFTERNOON — Television Session

Robert E. Lewis, Armour Research Foundation, Chicago, Ill., "A Color or Stereoscopic Frame-Sequential Television Viewer."

Sam H. Kaplan, Consultant, Chicago, Ill., "Theory of Parallax Barriers."

A. D. Fowler and H. N. Christopher, Bell Telephone Laboratories, Murray Hill, N.J., "Effective Sum of Multiple Echoes in Television."

Fred Barton and H. J. Schlafly, TelePrompter Corp., New York, "TelePrompter, New Production Tool."

J. A. Norling (Committee Chairman), Loucks and Norling Studios, New York, "Report of Stereoscopic Motion Pictures Committee."

MONDAY EVENING — Television Session

Nathan L. Halpern, Theater Network Television, Inc., New York, "Theater Television Progress."

M. C. Banca, RCA Victor Division, Industrial Equipment Section, Camden, N.J., "Industrial Television."

Victor Trad and Ricardo Muniz, Trad TV Corp., Asbury Park, N.J., "Dual Theater Television System."

John M. Sims, General Precision Laboratory, Pleasantville, N.Y., "Installing GPL Video Film in Denver's Broadway Theater."

W. H. Offenhauser, Jr., Consultant, New Canaan, Conn., "Nomenclature for Motion Pictures and Television."

TUESDAY MORNING — Screens and Control of Brightness

D. R. White (Committee Chairman), E. I. du Pont de Nemours & Co., Inc., Parlin, N.J., "Report on International Standardization."

Charles W. Handley (Committee Chairman), National Carbon Co., Inc., Los Angeles, Calif., "Report of the Progress Committee."

Arthur J. Hatch, Strong Electric Corp., Toledo, Ohio, "A-C High-Intensity Arc Slide Projector."

Benjamin Schlanger and William A. Hoffberg, Theater Consultants, New York, and Charles R. Underhill, Jr., RCA Victor Division, Camden, N.J., "The Synchro-Screen as a Stage Setting for Motion Picture Presentation."

W. W. Jennings, W. Wheeler Jennings, Chicago, Ill., and Pierre Vanet, A. Mattey, Paris, France, "A New Direct-Vision Stereo-Projection Screen."

Ellis W. D'Arcy and Gerhart Lessman, De Vry Corp., Chicago, Ill., "Objective Evaluation of Projection Screens."

H. B. Brueggemann, Cinecolor Corp., Burbank, Calif., "Continuous Arc Projector Light Meter."

TUESDAY AFTERNOON — Armed Forces Production

Max Beard and A. M. Erickson, Naval Ordnance Laboratory, Silver Spring, Md., "An Auditorium Specifically Designed for Technical Meetings."

Phillip M. Cowett, U.S. Navy, Bureau of Ships, Washington, D. C., "16mm Motion Picture Theater Installations Aboard Naval Vessels."

W. R. Cronenwett, U.S. Navy, U.S. Naval Photographic Center, Anacostia, D.C., "The Navy's Training Film Production Program."

Charles F. Hoban and James A. Moses, Motion Picture Branch, Army Pictorial Service Division, Washington, D.C., "Cameo Film Production Technique."

P. C. Foote, Bell & Howell Co., Chicago, Ill., and R. E. Miesse, General Scientific Co., Chicago, Ill., "Military-Type Lenses for 35mm Motion Picture Cameras."

TUESDAY EVENING — Magnetic Protection; Film Inspection

M. G. Townsley, H. H. Brauer, J. P. Weber and F. J. Schuessler, Bell & Howell Co., Chicago, Ill., "New Magnetic and Optical 16mm Sound Projector."

Robert Grunwald, Harwald Co., Evanston, Ill., "The Inspect-O-Film Machine."

Carl E. Hittle, RCA Victor Division, Hollywood, Calif., "Automatic Torque Controller for Torque Motors."

E. W. D'Arcy and J. S. Powers, De Vry Corp., Chicago, Ill., "Magnetic Sound Application to 16mm Armed Forces Projectors."

WEDNESDAY MORNING — High-Speed Photography Session

D. Muster and E. G. Volterra, Illinois Institute of Technology, Chicago, Ill., "Rotating-Drum Camera for High-Speed Experimental Work."

Brian O'Brien, Gordon Milne and William Covell, University of Rochester, Rochester, N.Y., "Automatic Printing of High-Speed Image-Dissection Negatives."

J. L. Tupper, Eastman Kodak Co., Rochester, N.Y., "Practical Aspects of Reciprocity Law Failure."

N. W. Rodelius, Armour Research Foundation, Chicago, Ill., and Eugene L. Perrine, Zonolite Research Laboratories, Evanston, Ill., "Methods of Improving Visibility in High-Speed Photography.'

WEDNESDAY AFTERNOON — High-Speed Photography Session

C. H. Winning, Du Pont Eastern Laboratory, Gibbstown, N.J., and H. E. Edgerton, Massachusetts Institute of Technology, Cambridge, Mass., "Explosive Argon Flash-lamp."

James Cooper, University of Michigan, Aero Research Laboratories, Willow Run Airport, Mich., "Photography in the Wind Tunnel, Including Schlieren and Flame Photography."

Ralph P. Sledge, International Harvester Co., Memphis, Tenn., "Portable Generating Equipment for Use With the Fastax Camera."

THURSDAY AFTERNOON — Color and Laboratory Session

John Stott (Committee Chairman), Du-Art Film Laboratories, Inc., New York, "Laboratory Practice Committee Report."

Robert C. Lovick, Eastman Kodak Co., Rochester, N. Y., "Exposure of Kodachrome Sound Tracks for Optimum Quality.

Robert C. Lovick, Eastman Kodak Co., Rochester, N.Y., "Densitometry of Silver Sulfide Sound Tracks."

F. P. Herrnfeld, Frank Herrnfeld Engineering Corp., Culver City, Calif., "Integrating-Type Color Densitometer."

A. A. Duryea, T. J. Gaski and L. Mansfield, Pathe Laboratories, Inc., New York, "Negative-Positive Color Processing by Pathe."

THURSDAY EVENING — General Session

Mauro Zambuto, Scalera Films, Rome and Venice, Italy, "Foreign Language Dubbing."

Thomas T. Hill, The Edwal Laboratories, Inc., Ringwood, Ill., "Nonsilver Photographic Processes."

H. L. Baumbach, Paramount Pictures Corp., Hollywood, Calif., "Effect of pH Upon Photographic Developer Activity."

John K. Hilliard (Committee Chairman), Altec Lansing Corp., Beverly Hills, Calif., "Sound Committee Report."

Otto Bixler, Magnecord, Inc., Chicago, Ill., "Commercial Binaural Tape Recorder."

FRIDAY MORNING — Sound and Editing Session

Chester E. Beachell, The National Film Board of Canada, Ottawa, Ontario, Canada, "Simplified Preamplifier With High Gain, Low Distortion, and Exceptional Dynamic Range and Frequency Response."

O. L. Dupy, Metro-Goldwyn-Mayer Sound Dept., Culver City, Calif., "A Method of Direct-Positive Variable-Density Recording With the Light Valve."

Chester E. Beachell and G. G. Graham, National Film Board of Canada, Ottawa, Ontario, Canada, "Dual-Purpose Optical Sound Prints."

R. M. Savini, Editola Corp. of America, New York, "The Editola Film Editing Machine."

Richard H. Ranger, Rangertone, Inc., Newark, N.J., "Tape-to-Film Editor."

Richard H. Ranger, Rangertone, Inc., Newark, N.J., "A Versatile Camera Car and Recording Unit."

FRIDAY AFTERNOON — New Equipments Session

A. L. Holcomb, Westrex Corp., Hollywood, Calif., "Three-Phase Power From Single-Phase Source."

Chester E. Beachell, The National Film Board of Canada, Ottawa, Ontario, Canada, "Multiple-Camera Control and Automatic Synchronizing System."

Benjamin Berg, Benjamin Berg Agency, Hollywood, Calif., "Professional Motion Picture Camera Which Utilizes Both 16mm and 35mm Film."

Lee R. Richardson and William N. Gaisford, Richardson Camera Co., Hollywood, Calif., "Follow-Focus Device and Camera Blimp for 16mm Professional Camera."

Willy Borberg, General Precision Laboratory, Pleasantville, N.Y., "Buckle Reduction in 35mm Film."

SMPTE Officers and Committees: The roster of Society Officers and the Committee Chairmen and Members were published in the April *Journal.*

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